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HUMAN FOOT LENGTH FROM EMBRYO TO ADULT

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THIS paper represents a colligation of materials on foot length from upwards of sixty studies. Included are several analyses of data drawn from previously unpublished investigations.

Consideration has been restricted to inhabitants of North and Central America. Within this geographic zone, an attempt has been made to compile and integrate all of the research information presently available on length of the human foot.

PRENATAL PERIOD

It is a morphologic commonplace that during the period of the ovum (*i. e.* the first two weeks following fertilization) the human organism registers no observable indications of lower extremities.

In the period of the embryo (*i. e.* between two and eight weeks after fertilization), lower limb buds protrude from the trunk, the feet become delimitable segments of the lower limbs, and foot length emerges as a morphologically definable (*e. g.* posterior of heel to tip of longest toe) and measurable dimension.

Bardeen and Lewis (1901) studied the earliest indications of the foot, or pes, utilizing 18 embryos between the approximate ages of two and seven weeks. Thirteen of their specimens belonged to the collection of Franklin P. Mall, and were housed in the Anatomical Laboratory of the Johns Hopkins University, Baltimore, Maryland. These were supplemented with five embryos of "the His collection".

On the one specimen younger than four weeks (crown-rump length .2 cm.) there were "no external visible signs of limb buds" (p. 4). For each of five specimens in the fifth week (crown-rump lengths .4 cm. to .5 cm.), the lower extremities were "represented by a slight swelling opposite the 1st to 5th lumbar and 1st sacral myotomes" (p. 4). In two embryos approximately six weeks of age (crown-rump length 1.1 cm.) there was "distinct differentiation of the foot" (p. 8). Specifically, for both these embryos the distal part of each lower extremity was "flattened so that it presented median and lateral surfaces", and there was a constriction "immediately beyond the region where the distal flattened portion of the limb joined the thicker rounded base" (p. 13). Additional observations were given on one embryo each in the seventh and eighth weeks. The former (crown-rump length 1.3 cm.) had foot plates or disks upon which digitation had "begun", while the latter (crown-rump length 2.0 cm.) showed "fairly distinct" toes. For both specimens the "twist at the ankle" had not begun, so that the foot lay "in the same plane with the leg" (p. 9).

A second paper dealing with the stage in embryonic growth when the "free extremity of the limb-bud becomes flattened and differentiated into the anlage of the foot" was published by Bardeen (1905). Again, the subjects were a small series of human embryos "belonging to the collection of Prof. Mall, at the Johns Hopkins University, Baltimore" (p. 265). Bardeen epitomized his findings as follows: "In Embryos CCXLI, length 6 mm.; II, length 7 mm.; CLXIII, length 9 mm.; and CCXXI, length 13 mm., I find no distinct signs of a foot-plate. In each of the following embryos I find a foot-plate which has not distinctly undergone further differentiation: CIX, length 11 mm.; CLXXV, length 13 mm." (p. 290).

Arey (1934), in a textbook characterization of the typical sequence of foot development "between the fifth and eighth weeks," has succinctly stated: "The limb buds appear during the fifth week as lateral swellings . . . The distal end of a limb bud flattens and a constriction divides this paddle-like portion from a more proximal, cylindrical

segment . . . Radial ridges, separated by grooves, first foretell the formation of digits. These elongate into definitive . . . toes," and the great toe "separates widely" from the second toe (pp. 144-145).

Particularly pertinent with reference to the measurement of foot length is the pattern of toe projection (the digital formula) of the foot in late embryonic and early fetal life. This has been studied by Schultz (1924) and by Straus (1927).

Schultz, in a preliminary report (1923), stated that his findings were based on an examination of "623 of the best of the normal and well-preserved specimens, both White and Negro," from a collection of "over 5,000 human embryos and fetuses in the Carnegie Laboratory of Embryology" (p. 389). According to this report, it had been found that "in a fair percentage of fetuses from the end of the second and the beginning of the third month the middle toe is the longest. Very soon afterward the second toe becomes the longest in a large majority of cases; not until the fourth month does the great toe project farther than any of the other toes, and then only in a small minority of cases. The frequency of instances in which the great toe is shorter than the toe II decreases . . . with advance in fetal development, but such cases always remain much more common in the Negro than in the Whites" (pp. 395-396). In his more detailed presentation (1924) Schultz cast these findings in more specific and quantitative form. To quote: ". . . in fetuses of the eighth and ninth week the digital formula may read: $3>4>2>1>5$ . . . at ten weeks the formula has, as a rule, become altered to: $2>3>4=1>5$; at twelve weeks it is most frequently in Whites: $2>3=1>4>5$, and not until the eighteenth week does it become characteristic for the White human fetus to show the following formulae: $2=1>3>4>5$ (44 percent of specimens) and $2>1>3>4>5$ (40.5 percent), while in Negroes of that age it is on an average: $2>3>1>4>5$" (pp. 158-159).

The study by Straus was also made at the Embryological Laboratory of the Carnegie Institution of Washington, and presumably utilized some of the same specimens employed by Schultz. Straus' specimens numbered 50 —"29 Whites, 12 Negroes and nine of unknown race, either White or Negro" (p. 100). Seven were grouped in the age period from "the eighth to the twelfth weeks (crown-rump length 2.3 cm. to 5.4 cm.)", 14 in the fourth month (crown-rump length 6.4 cm. to 10.7 cm.), eight in the fifth month, and the remaining 21 in prenatal months six to nine. The findings were: "Of seven fetuses

of the eighth to the twelfth week, in three the second toe was the longest, in four the third toe . . . In all of the 14 fourth-month fetuses the second toe was the longest. In no specimen younger than the fifth month was the big toe the most prominent; indeed, during even the last half of prenatal life, toe I was the longest in only 25 percent of the individuals examined" (p. 129).

Growth in foot length during the fetal period has been studied by Streeter (1920) and by Scammon and Calkins (1929). The former utilized 704 specimens of the collection at the Embryological Laboratory of the Carnegie Institution. The specimens had been sent in by various physicians largely between 1915-20. They were predominantly "specimens of the first half of pregnancy" and "chiefly from abortions" (p. 151). All were morphologically "normal" in appearance. "By far the greater number" were of White ancestry and these were "about equally divided as to sex" (p. 152). For the total series, the numbers were as follows: "White males 252; White females 241; Negro males 66; Negro females 60; other races, males 15, females 11; unidentified as to race or sex 59" (p. 152). "Much of the material was accompanied by clinical records of the menstrual age" (p. 145).

Fixative conditions were "maintained as nearly uniform as possible" (p. 145). All specimens were preserved in 10 per cent formalin solution for a period of two weeks prior to measurement. "Some fetuses of over 400 grams weight were embalmed with a 10 per cent formalin solution injected through the umbilical artery" (p. 148).

Foot length was "taken with a small sliding compass, the length being measured from the posterior surface of the heel to the tip of the first or second toe, whichever was the longer. Where there was a difference in the size of the two feet the longer one was recorded" (p. 150). The foot was "held as straight as possible during the measurement" and "the determinations were made for the most part by the same person" (p. 145, 150).

The centimeter increase in mean foot length (see Table 1) was found to be greater between four and six lunar months (menstrual age) than between either two and four months or six and eight months. In general, the percentage increments in mean foot length indicated a slowing rate of growth with each successive month.

On transposing the age scale into approximate equivalents for fertilization age (true age of the organism) in calendar months, mean foot length was interpolated as 1.5 cm. at age three months, 3.5 cm.

TABLE 1

Foot length (cm.) of "normal" fetuses accumulated at the Carnegie Laboratory of Embryology c. 1915-1920

MENSTRUAL AGE		MEAN	RANGE	GAIN IN MEAN	
(wks.)	*(lunar mos.)*			*Absolute*	*Percentage*
8.5	....	.4	....	....	....
12	3	.9	.7 - 1.1	....	....
16	4	2.0	1.8 - 2.2	1.1	119
20	5	3.3	3.1 - 3.6	1.3	67
24	6	4.5	4.2 - 4.9	1.2	36
28	7	5.5	5.1 - 5.9	1.0	22
32	8	6.3	5.9 - 6.7	.8	14
36	9	7.3	6.9 - 7.8	1.0	17
40	10	8.2	7.7 - 8.7	.9	12

at the midpoint of the prenatal period (4.5 months), and 5.4 cm. at age six months. The zone of individual differences at age six months extended from approximately 5.0 cm. to 5.8 cm.

Scammon and Calkins' analysis of measurements of foot length was based on a series of 299 human fetuses ranging in stature ("crown-heel length") from 5.0 cm. to 54.4 cm. The series formed "part of the collections of the Department of Anatomy and the Department of Obstetrics and Gynecology of the University of Minnesota" and was "selected from a much larger group by discarding all soft and distorted specimens" (p. 2). "Only Caucasian material was used . . . the material came from the Minneapolis General Hospital, the Elliott Memorial Hospital of the University of Minnesota, and similar local institutions" (p. 3).

The specimens were "preserved in 10 per cent formalin solution . . . for at least six months before they were measured" (p. 3). "The majority of specimens of 35 cm. or more crown-heel length were also injected through the umbilical vein with a considerable amount of 10 per cent formalin alone or with the addition of 1 per cent chromic acid at the time of their preservation" (p. 3).

Foot length was measured "as a straight line from the posterior margin of the heel to the tip of the extended great toe" (p. 245). Apparently, records were secured for "the right limbs only" (p. 215).

In the main, the measurements were made during the period 1919-21 by Drs. Raymond Dittrich and Leroy A. Calkins.[1]

Direct distribution of the data by age groups was not possible "since few of the specimens were accompanied with clinical histories from which the age could be estimated with any accuracy" (p. 47). Alternatively, primary grouping of the data was made "on the basis of the total or crown-heel length" (p. 29). Ten successive "5 cm. interval" groups were formed. For each group, the mean foot length was calculated and notation made of the minimum and maximum values. In order to obtain approximate age equivalents for the means of the stature groups "18 of the more complete sets of data on body-length and prenatal age" were examined, and the set by Mall (1910), which represented "by far the largest group of cases", selected as "the best available" (pp. 47-48) (see Table 2).

TABLE 2

Foot length (cm.) of Minnesota White fetuses largely of northwest European ancestry

CROWN-HEEL LENGTH *(cm.)*		NUMBER OF SPECIMENS	FOOT LENGTH		MEAN MENSTRUAL AGE *(lunar mos.)* AS ESTIMATED FROM MALL'S (1910) STUDY
Mean	Range		Mean	Range	
7.8	5 - 10	21	.8	.5 - 1.0	3.1
12.5	10 - 15	38	1.3	1.0 - 1.8	3.6
17.2	15 - 20	26	2.0	1.7 - 2.4	4.2
22.5	20 - 25	47	2.9	2.2 - 3.8	5.0
27.1	25 - 30	42	3.7	3.1 - 4.3	5.7
32.6	30 - 35	32	4.7	4.0 - 5.6	6.5
37.0	35 - 40	30	5.3	4.5 - 6.0	7.3
42.1	40 - 45	17	6.0	5.3 - 6.9	8.3
47.3	45 - 50	23	6.9	6.4 - 7.7	9.4
52.5	50 - 55	23	7.7	7.1 - 8.7	....

Using the means for foot length as ordinate values and those for estimated menstrual age as abscissa values, a central tendency curve was drawn and the following interpolations read:

[1] It will be recognized that the anthropometric technique here is not identical with that employed by Streeter (1920). The Streeter procedures would tend to yield higher means, particularly so in the earlier fetal months.

Menstrual age *(lunar mos.)*:	3	4	5	6	7	8	9
Approx. mean foot length *(cm.)*:	.7	1.7	2.9	4.1	5.0	5.8	6.6

The centimeter increase in pes length was greater between three and six lunar months (3.4 cm.) than between six and nine lunar months (2.5 cm.). The percentage increase diminished month by month:

Age interval *(lunar mos.)*:	3-4	4-5	5-6	6-7	7-8	8-9
Approx. percentage increase	143	71	41	22	16	14

Corrected to approximate fertilization age, mean foot length may be estimated as 1.3 cm. at three calendar months, and at the five successive calendar months as 2.5 cm., 3.8 cm., 4.9 cm., 5.7 cm. and 6.5 cm. respectively. At the midpoint of the prenatal period (4.5 calendar months), this study appears to yield a mean foot length of approximately 3.1 cm.

The foregoing materials pertaining to growth in foot length during intrauterine life may be summarized as follows:

1. The anlagen of the human feet, or pedes, begin to protrude from the body stem during the fifth week after fertilization as part of the lower limb buds. By the end of the sixth week the feet have become fairly well circumscribed plates of tissue, though they still lie approximately along the same axes as the shafts of the legs. Gradually, these plates develop four fan-shaped grooves distally, and begin to turn out of the leg planes. At the close of the eighth week each pes is normally characterized by discrete toes and a definitely indicated heel contour.

2. When the heel contour is first delineated (eighth week), the middle toe may be the most forward projecting of the pedal digits. Typically, the second toe is longer than the hallux (first or great toe) from the third prenatal month through the sixth. The relevance of these and later changes in digital relationship to the problem of defining and measuring foot length is obvious.

In addition to appreciating the advantages of a standardized anthropometric technique for determining fetal foot length (particularly with reference to the anterior landmark), it is pertinent to recognize: (a) the possibility that a slight systematic error accrues from employing preserved specimens, and (b) the difficulty of securing fetuses whose records yield reasonably precise information for age. The extent to which foot length on fetal specimens preserved in 10 per cent formalin differs from that on living fetuses of like age has not been shown. It is self-evident that valid data for the study of *variability*

in foot length presupposes the accessibility of a large series of fetuses for whom age can be calculated directly and depended upon as accurate within fairly narrow limits.

3. Eight weeks after fertilization, mean foot length (*i. e.* the straight line distance from the hindermost point of the heel to the tip of the longest toe) approximates one-fifth of an inch. Approximate means at selected later ages are three-fifths of an inch at three months and two inches at six months. The rate of growth in mean foot length tends to decrease continuously; during the fourth prenatal month the foot more than doubles its length, in the sixth month its increase is reduced to less than 50 per cent, and in the last month before birth the increment does not exceed 15 per cent. Absolute variability in foot length becomes somewhat greater with age, though at no intrauterine age have individual differences been shown to exceed three-fifths of an inch.

INFANCY

Within the interval from birth to the end of the second postnatal year, twelve studies are available. Initially, each of these studies will be reviewed. Their results will then be utilized to formulate a series of generalized statements on growth in foot length during human infancy.

Talbot (1924b) collected 30 measurements of foot length on infants "organically sound," though "from four to ten weeks premature" (p. 30). "The criteria used in establishing prematurity were weight, stature, and general considerations, such as facies, texture of the skin, undeveloped nails, cry, unstable temperature and history of expected birth" (p. 30).

The subjects were 10 males and 10 females. They were born 1920-22, and housed partly at the Boston Lying-In Hospital and partly at the Children's Department of the Massachusetts General Hospital. When measured, they ranged in postnatal age from seven days to seventeen months. Twelve were measured once, seven twice, and one at five ages.

Foot length of premature infants at postnatal ages 7 to 45 days

AGE GROUP			STATURE		WEIGHT		FOOT LENGTH	
Mean	Range	N	Mean	Range	Mean	Range	Mean	Range
(days)			*(cm.)*		*(gm.)*		*(cm.)*	
12	7-18	10	43.1	38.0-46.5	1660	1304-2098	6.5	6.0-7.8
30	21-45	13	45.1	38.0-47.7	1857	1191-2339	6.7	6.0-7.2

Compared with the means for foot length presented in the previous section, these means are similar to those on normal fetuses at about eight calendar months after fertilization.

The subject measured on five different occasions—a female—had foot length records of 6.1 cm. at two weeks, 7.3 cm. at 2.2 months, 7.6 cm. at 3.2 months, 10.8 cm. at fourteen months, and 10.4 cm. at seventeen months. Only one other record was obtained at a postnatal age above three months; this was a single measurement of 11.5 cm. on a male infant aged sixteen months.

Bakwin and Bakwin (1934) studied sex and birth order differences in length of the foot "at term." The subjects were 261 White infants born in New York City at the Bellevue Hospital, Fifth Avenue Hospital, New York Nursery and Child's Hospital, and New York Infirmary for Women and Children.

Description of the anthropometric procedure, covering both landmarks employed and orientation of the foot, was afforded in an earlier (1931) paper: *"Length of foot.* From the point on the heel over the tuber calcanei which projects furthest back to the tip of the great toe with the foot held at right angles to the leg, in a line parallel to the internal margin of the foot" (p. 373). All measurements were made by one anthropometrist, Miss Allene Jones.

Foot length (cm.) of New York City newborns "by sex and order of birth"

	MALES				FEMALES			
BIRTH ORDER	N	Mean	S. D.	V	N	Mean	S. D.	V
First-born	71	7.9	.38	4.8	79	7.8	.33	4.2
Later orders	62	8.0	.42	5.2	49	8.0	.39	4.9
All orders	133	7.9	.40	5.0	128	7.9	.36	4.6

Inspection of the birth order values indicates a slight tendency for foot length to be shorter on first-born neonates than on neonates of later birth orders. For males, the difference is not statistically significant (t=1.7); for females, it is significant at the 1 per cent level of confidence (t=3.2).

Goodman (1941) studied foot length at birth on 120 White infants born in 1941 at the University Hospitals, Iowa City, Iowa. Infants were taken serially as birth occurred except for the exclusion

of those weighing less than 2500 gm., those placed under special observation, and those with talipes. Sixty subjects of each sex were taken. They were almost exclusively of northwest European ancestry, and represented "a downward selection with respect to socio-economic status" (90 per cent of the mothers were receiving maternity care as charity cases). In every instance, measurements were made on the day of birth.

The procedure in taking foot length was (a) to raise the infant's left leg from the measuring table, (b) to orient the sole of the foot at right angles with the leg, and (c) to measure the straight line length from the posterior of the heel (pternion) to the most anterior point of the great toe. Wooden sliding calipers of an especially reduced size were used. In securing all records an attempt was made to elicit the greatest possible extension of the hallux.

On each infant examined, the difference was obtained between independent measurements of left pes length taken by two anthropometrists. Sixty-nine per cent of these differences did not exceed 0.1 cm., 28 per cent were 0.2 cm. or 0.3 cm., and the remaining 3 per cent 0.4 cm. In terms of the Pearson product-moment method of correlation, the independent measurements of anthropometrists A and B yielded a reliability coefficient of .89.

A single representative record of pes length for each subject was derived in the following manner. Where the difference between the independent readings by anthropometrists A and B did not exceed 0.2 cm., the mean of the two readings was taken. Where a difference of 0.2 cm. was exceeded, "each anthropometrist made an additional determination and the mean of the four readings was taken" (p. 23).

Foot length (cm.) at birth of White infants born in Iowa City 1941

SEX	N	MEAN AND MEDIAN	S. D.	V	PERCENTILES 25th	PERCENTILES 75th	RANGE
Males	60	8.0	.32	4.1	7.8	8.2	7.3 - 8.7
Females	60	7.8	.29	3.7	7.6	8.0	7.7 - 8.5

These figures register a slight tendency for male neonates to exceed female neonates in foot length. They also confirm the findings of Bak-

win and Bakwin that the foot length of newborn females is less variable than that of males.

Ito (1936) obtained measurements of foot length on 202 full-term infants of Japanese ancestry born between 1932 and 1935 in Los Angeles, California. Approximately 56 per cent of the mothers were primiparae. The fathers were "laborers, farmers, horticulturists, clerks, small merchants, public officials and professional men. The majority were of the laboring class but were comparatively well-to-do for Japanese in California" (p. 321).

Length of the foot, "from the heel to the tip of the great toe", was measured "with a steel tape" (p. 323). The measurements were taken between birth and the seventh postnatal day, the majority being made "on the third, fourth, or fifth day" (p. 321).

Foot length (cm.) of Los Angeles neonates of Japanese ancestry

AGE GROUP		MALES			FEMALES		
Median *(days)*	Range	N	Mean	Range	N	Mean	Range
4	0 to 7	94	8.1	7.2 - 9.3	108	7.9	7.0 - 9.0

Compared with means from samples of American-born White neonates, Ito's means for American-born neonates of Mongoloid descent are not appreciably different. Specifically, they are slightly higher than the means obtained from some White samples and slightly lower than those obtained from others. It must not be overlooked that Ito's measurements were made with a steel tape, which seemingly implies that projections from the landmarks to the tape were made by eye.

Taylor (1919) analyzed measurements of foot length (distance "from the heel to the tip of the toes") on 250 infants characterized as "normal and born at term" (p. 353). The data were collected between 1914 and 1917 at the University Hospital, Minneapolis—a charity hospital admitting primiparous women almost exclusively. "Eighty-one per cent of the babies were measured on the fourth, fifth, or sixth day of life, none earlier than the second, and none later than the tenth" (p. 353). Roughly two-fifths of the mothers were of Scandinavian ancestry, two-fifths of other northwest European stocks, and one-tenth Jewish.

Foot length (cm.) of Minneapolis neonates, predominantly first-born

AGE GROUP Median (days)	Range	MALES N	Mean	Range	FEMALES N	Mean	Range
5	2 to 10	125	8.3	6.7 - 9.6	125	8.1	7.2 - 9.2

As for the studies by Ito and Goodman, the central tendency value on the male subjects is higher than that for the females.

Cates and Goodwin (1936) reported an analysis of data for pes length accumulated on 669 neonates "born in the Obstetrical Department of the Toronto General Hospital" during the three-year period 1933-35 (p. 433). The subjects were "normal," full-term (*i. e.* neither "premature" nor "over-term") infants. They were examined "in a great majority of cases on the twelfth day—never earlier than the eleventh and never later than the fourteenth" (p. 438).

Pes length was measured with sliding calipers and was seemingly taken, following Scammon and Calkins, as the distance from the posterior margin of the heel (pternion) to the tip of the extended great toe. The measurements were made by Drs. D. Borsook, J. C. Goodwin, and D. Irwin. In order "to determine the precision" of the data, Borsook made 30 separate determinations on one subject. "This was done at one sitting and an independent observer read the instrument and noted the result each time" (p. 435). The 30 records distributed themselves from a minimum reading of 8.2 cm., through a mean of 8.5 cm., to a maximum reading of 8.8 cm.

Foot length (cm.) of Toronto neonates born 1933-35

AGE GROUP Median (days)	Range	MALES N	Mean	S. D.	V	FEMALES N	Mean	S. D.	V
12	11 thru 14	343	8.4	.49	5.8	326	8.2	.45	5.5

The typical male infant of the second postnatal week was found to have a slightly longer foot than the typical female. Further, compared with the female, "the male showed somewhat greater variability" (p. 445).

Richdorf (1925) accumulated approximately 600 measurements of foot length distributed over the first postnatal year. The subjects were 390 White infants ("majority of Northern European extraction") residing in Minneapolis, St. Paul, and Rochester, Minnesota. All were considered negative for congenital abnormality, prematurity, birth injury, acute and chronic disease, and "nutritional disorder." Their fathers were "skilled workmen, tradesmen, or professional men" (p. 14). "Medical attention and instruction in child care was available for the mothers . . . Solid food (cereal well cooked) was begun from the fourth to the seventh month, and vegetables about a month later . . . Orange juice was given in all cases . . . Cod liver oil and sunlight were recommended almost routinely" (pp. 15-16).

Foot length was measured "as a straight line from the posterior margin of the heel to the tip of the extended great toe, or to the second toe, in those cases where it was the longer digit. The actual measurement was made with the type of caliper used by the shoemaker in determining the length of the foot and the size of the shoe. The readings were taken from the instrument with a millimeter scale" (p. 43). Findings at selected ages are shown in Table 3: Average foot length

TABLE 3

Foot length (cm.) of Minnesota urban infants of middle and upper classes

AGE GROUP			MEAN AND			PERCENTILES		
Midpoint	Range	N	MEDIAN	S. D.	V	25th	75th	Range
			Males					
7 days	3 to 10	24	7.9	.27	3.5	7.7	8.0	7.4 - 8.6
6 wks.	4 thru 7	25	8.3	.39	4.7	8.0	8.6	7.3 - 9.0
3 mos.	2 thru 3	50	8.9	.47	5.2	8.7	9.2	7.8 - 10.0
6 mos.	5 thru 6	50	9.9	.54	5.5	9.5	10.3	8.7 - 11.0
9 mos.	8 thru 9	49	10.5	.50	4.8	10.2	10.9	9.6 - 11.7
11 mos.	10 thru 11	50	10.9	.57	5.3	10.5	11.2	9.7 - 12.3
			Females					
7 days	3 to 10	23	7.8	.22	2.9	7.6	7.9	7.3 - 8.2
6 wks.	4 thru 7	25	8.3	.36	4.3	8.2	8.5	7.4 - 9.3
3 mos.	2 thru 3	50	8.6	.42	5.0	8.3	8.9	7.7 - 9.8
6 mos.	5 thru 6	48	9.7	.50	5.2	9.3	10.0	8.6 - 11.0
9 mos.	8 thru 9	47	10.4	.55	5.3	10.0	10.7	9.1 - 11.5
11 mos.	10 thru 11	48	10.8	.50	4.2	10.5	11.1	9.8 - 12.1

one week after birth was 7.9 cm. for males and 7.8 cm. for females. For each sex, the average at eleven postnatal months was 3.0 cm. (approximately 38 per cent) greater than at one week. Between one week and six months the increases in average were double those between six and eleven months. At different ages, the central one-half of the foot lengths fell within zones varying from 0.3 cm. to 0.8 cm. At no age studied did the range of a distribution exceed 2.6 cm. The overlapping of distributions was considerable, there were individual infants examined at age eleven months who had feet as short as other infants aged three months.

Central tendency and variability values for foot length were reported by Bakwin and Bakwin (1936) at several ages during the first postnatal year. The data were obtained from about thirteen hundred examinations made on 198 White infants (94 males and 104 females) born at the Fifth Avenue Hospital, New York City, and "supervised from birth in a special clinic" for well infants. The subjects were described as mainly of North European, Mediterranean or Jewish lineage, and "from homes of moderate income" (p. 177). Foot length was measured from the pternion to the tip of the great toe, in a line parallel with the internal margin of the foot. Table 4 reproduces the values secured for six age-sex subgroups. The investigators stated that central tendency figures for intermediate ages could be "readily obtained by constructing curves from the mean values afforded and interpolating" (p. 177). Following this suggestion, mean foot length at age six months is 10.0 cm. for males and 9.6 cm. for females.

TABLE 4

Foot length (cm.) on New York City infants of middle classes

AGE GROUP		MALES			FEMALES		
Midpoint	Range *(wks.)*	Mean	S. D.	V	Mean	S. D.	V
2	0 thru 3	8.0	.41	5.2	7.8	.38	4.8
6	4 thru 7	8.4	.42	5.0	8.1	.41	5.0
12	8 thru 15	8.9	.50	5.6	8.7	.43	5.0
28	24 thru 31	10.1	.48	4.8	9.7	.40	4.1
40	36 thru 43	10.8	.59	5.4	10.5	.52	4.9
52	48 thru 55	11.6	.52	4.5	11.2	.48	4.3

Davenport (1938) published figures representing pes length "at about one month and at about one year" (p. 281). He accumulated his data during the years 1933-37 at the Normal Child Development Study, Babies Hospital, New York City. The subjects were 34 normal infants, 19 males and 15 females. Almost 80 per cent were of northwest European descent, with the remainder largely of Italian ancestry. All were considered to have been so fed that "the vitamin requirements for growth were satisfied" (p. 275).

Measurements were taken on the right pes. An estimate of their reliability was derived from individual growth curves. This was possible since each subject had been examined at frequent intervals and his successive records plotted against age and smoothed. The difference was obtained between each measured value and "the probable value as estimated by smoothing" (p. 277). The average of these difference values was 0.09 cm.

Foot length (cm.) of New York City infants

I MONTH			I YEAR		
Mean	S. D.	V	Mean	S. D.	V
8.2	.58	7.1	11.4	.31	2.7

It was not stated whether the full 34 subjects were examined at each age. The sexes were not separated. Mean foot length at one year was found to exceed that at one month by 3.2 cm., or more than 39 per cent.

Talbot (1924a) collected measurements of foot length on approximately 200 "clinically normal American children" between the postnatal ages of two weeks and two years. The subjects were considered "average children within the accepted normal limits of height and weight for age" and were claimed "not to represent exceptionally well nourished or poorly nourished children" (p. 541). Roughly half were males and half females. Foot length was measured "from the heel to the tip of the great toe" (p. 546).

For each sex separately, the records on every individual for age (abscissa value) and foot length (ordinate value) were "plotted on charts, and a smoothed curve drawn to indicate the trend of growth" (p. 541). Two points should be noted with the reference to these curves; they "do not represent mathematical averages" and, as pub-

lished, they are difficult to read. It is estimated that the trend line for males (p. 548) passes through 9.8 cm. at three months, 10.9 cm. at six months, 12.1 cm. at one year, 13.0 cm. at eighteen months, and 13.8 cm. at two years. The trend line for females (p. 548) appears to pass through 9.0 cm. at three months, 10.0 cm. at six months, 11.8 cm. at one year, 13.0 cm. at eighteen months, and 14.2 cm. at two years. That these figures must be regarded as no more than crude estimates of central tendency is attested by the fact that duplicated trend lines covering the early months of the first year (p. 554) yield foot length estimates at age three months of 10.2 cm. for males and 9.4 cm. for females.

A series of foot length records secured from frequent measurement of a single male infant over the first eighteen months of postnatal life was published by Hall (1896). The child was "physically perfect" at birth and, "except for an attack of whooping-cough," enjoyed continuous "good health" (p. 331). He lived in Switzerland until six months of age, in Illinois after ten months. His father's ancestry was "purely American," his mother's "purely English." The education of both parents included "college and university studies" and both were professionally interested in child development. In Switzerland and in the United States, the child was "in the open air from one to three hours every dry day, even in the coldest weather" (p. 332).

Length of the nude foot was measured with wooden calipers "from the posterior surface of the calcaneum to the tip of the first or second digit." The measurements were made "with the most conscientious and painstaking exactness" (p. 333).

Foot length (cm.) on a "normal and healthy" male of a "well-to-do" family

1 MO.	3 MOS.	6 MOS.	9 MOS.	12 MOS.	15 MOS.	18 MOS.
8.1	8.6	9.5	10.4	11.2	11.7	12.6

The gain in foot length between the ages of one and eighteen months was 4.5 cm., or over 55 per cent. For the semi-annual intervals three to nine months and twelve to eighteen months the percentage increments were 20.9 (1.8 cm./8.6 cm.) and 12.5 (1.4 cm./11.2 cm.) respectively.

Meredith (1943) studied pes length during the first postnatal year with special reference to individual differences in amount of gain and

TABLE 5

Foot length records (cm.) for sixteen Iowa City White infants

SUBJECT	BIRTH	1 MO.	3 MOS.	6 MOS.	9 MOS.	12 MOS.	SOCIO-ECONOMIC GROUP
			Males				
5377	8.3	8.9	10.0	10.9	11.4	11.9	Managerial
5329	8.3	8.7	9.6	10.3	10.8	11.2	Unskilled
7458	7.9	8.6	9.5	10.2	10.7	11.3	Unskilled
4929	7.7	8.3	9.1	10.4	11.2	12.0	Professional
8073	8.2	....	9.7	10.8	11.3	12.1	Professional
7596	7.6	....	....	9.7	10.3	11.0	Unskilled
8929	7.9	8.3	9.0	9.7	10.6	....	Unskilled
8553	7.7	....	8.8	9.9	10.6	....	Semiskilled
Mean	8.0	8.6	9.4	10.2	10.9	11.6	
			Females				
6775	7.8	8.3	9.1	9.7	10.1	10.7	Professional
7610	7.7	8.3	9.2	10.2	....	11.4	Professional
76	7.9	....	9.2	10.1	10.5	11.0	Semiskilled
5858	7.7	....	....	9.7	10.6	11.3	Professional
1910	8.2	8.6	9.3	9.8	10.3	....	Professional
4824	7.9	8.4	9.3	10.2	10.7	....	Professional
9499	7.8	8.4	9.3	10.4	11.1	....	Managerial
7514	7.8	....	9.2	9.8	10.3	....	Unskilled
Mean	7.9	8.4	9.2	10.0	10.5	11.1	

in pattern of growth. Seriatim records (See Table 5) covering the period from birth to nine months or one year were obtained on 16 White infants born 1941-42. The subjects were all residents of Iowa City, Iowa, and of northwest European (predominantly British and/or German) descent. Eight were drawn from the professional and managerial classes and eight from the unskilled and semiskilled groups.

Measurements were made on the left pes from pternion to the tip of the extended hallux. The instrument, segment orientation, and procedures in basing each record on no less than two independent measurements were the same as described for the study by Goodman.

Selected findings from intercomparison of the records in Table 5 are:

1. Subjects 5377 and 5329 had identical foot lengths at birth. At age one year, the foot length of Subject 5377 exceeded that of Subject 5329 by 0.7 cm., or 6 per cent. Subject 5377 was (a) artificially fed from birth; (b) given orange juice and cod liver oil from the third week, egg yolk and cereal from the fifth month, and vegetables beginning at six months; and (c) entirely free from illness throughout the year. Subject 5329 was (a) breast fed for one month; (b) given orange juice and cod liver oil beginning the third week, egg yolk and fruits from three months, and vegetables from six months; and (c) ill with colic the first month, a severe cold most of the fifth month, a less severe but almost continuous cold from six to nine months, and chicken pox at ten months.

Similarly, Subjects 6775 and 9499 gave identical values at birth, while at nine months the foot of Subject 9499 was the longer by 1.0 cm., or 10 per cent. Subject 9499 was (a) breast fed for three weeks; (b) given orange juice and cod liver oil from six weeks, egg yolk and fruits from three months, and vegetables from five months; and (c) ill with a digestive difficulty the first month and colds in the second, eighth and nine months. Subject 6775 was (a) breast fed for six months; (b) given orange juice and cod liver oil from six weeks, egg yolk from ten weeks, cereal and vegetables from six months, and fruits from eight months, and (c) entirely free from illness except for three minor head colds between five months and nine months.

2. Compared with the foot length of Subject 5329, the foot length of Subject 4929 was shorter by 0.6 cm. at birth, practically equivalent at six months, and longer by 0.8 cm. at one year. The dietary and health history of Subject 5329 has been characterized above. Subject 4929 was (a) breast fed for three months; (b) given orange juice and cod liver oil from six weeks, egg yolk from three months, fruits from four months, and vegetables from five months; and (c) ill with recurrent colic the first third of the year, a severe cold in the eleventh month, and "intestinal flu" in the twelfth month.

The foot lengths of Subjects 76 and 4824 were equal at birth and practically coincided at ages three, six and nine months. Subject 4824 was (a) breast fed for three weeks; (b) given orange juice and cod liver oil from two weeks, custard from four months, fruits and vegetables from six months; and (c) ill for a few days with a diges-

tive upset in the third month and with a mild cold of three weeks duration in the sixth month. Subject 76 was (a) breast fed to nine months; (b) not given orange juice before three months, cold liver oil (or other Vitamin D supplement) before eight months, or egg yolk until after nine months; and (c) ill with slight colds in the first and second month, mild symptoms of red measles in the third month, and a minor cold in the eighth month.

Using the figures from the foregoing tabulation at birth, six months, and one year, individual increment values were derived for the periods birth to six months and birth to one year. The results, statistically reduced, are as follows:

Gain in foot length (cm.) of Iowa City White infants

SEX	BIRTH TO 6 MONTHS			BIRTH TO 12 MONTHS		
	N	Mean	Range	N	Mean	Range
Males	8	2.3	1.8 - 2.7	6	3.6	2.9 - 4.3
Females	8	2.1	1.5 - 2.6	4	3.3	2.9 - 3.7
Both sexes	16	2.2	1.5 - 2.7	10	3.5	2.9 - 4.3

The differences for males and females are not statistically significant. For both sexes together, the mean gain between birth and one year was 3.5 cm., while two-thirds of the subjects made gains between 3.1 cm. and 3.9 cm.

Included among the subjects measured both at birth and at one year were six infants of the professional and managerial classes and four of the laboring class. The mean gain was 3.7 cm. for the former and 3.2 cm. for the latter. The difference is not statistically significant. It is mentioned only as a lead for study on considerably larger samples.

Subject 4929 (see Table 5, row four, for seriatim data between birth and one year) was also followed throughout his second postnatal year. The measurements obtained were 12.8 cm. at fifteen months, 13.4 cm. at eighteen months, 13.9 cm. at twenty-one months and 14.4 cm. at twenty-four months. Total gain from birth to age two years was 6.7 cm., or 87 per cent.

In introducing this section on "Infancy," two aims were projected. The first has been accomplished. Materials relating to growth in foot

length during infancy have been presented from each of twelve investigations. It now remains to attempt a synthesis of these materials.

1. The data for the various investigations were collected over half a century and drawn from seven geographic areas. With the exception of the series of infants of Japanese ancestry studied by Ito in Los Angeles, the geographic areas were all within the boundaries of 40° to 45° W. latitude and 70° to 95° W. longitude. The earliest of the twelve investigations was that published by Hall in 1896. It is of historical interest that this was a longitudinal study made on a normal infant.

2. There is considerable variation among the studies in anthropometric procedure. The majority of the investigators used the tip of the hallux as the anterior landmark; Richdorf and Hall measured to the tip of the longest toe. Few investigators designated the foot measured; Goodman and Meredith used the left, Davenport the right. Different instruments used were "a steel tape" (Ito), "the type of caliper used by the shoemaker" (Richdorf), and especially adapted wooden sliding calipers (Goodman and Meredith). Descriptions of technique vary from no more than an indefinite reference to the landmarks employed ("from the heel to the tip of the toes") through to the reasonably adequate treatment of all relevant items by Goodman. Quantitative materials bearing on reliability are afforded by Cates and Goodwin, Davenport, and Goodman. Other investigators giving careful attention to rigorousness of anthropometric technique include Bakwin and Bakwin, Hall, and Meredith.

3. Over the period from birth to one year, it was possible to pool findings from several studies and thereby derive moderately dependable general means for the foot length of full-term, physically normal, White infants. Means for each sex at birth were obtained by combining the data of Bakwin and Bakwin, Goodman, Richdorf, and Taylor. At successive quarterly ages to one year, the findings of Bakwin and Bakwin, Meredith, and Richdorf were merged. On males, mean foot length approximates 3.2 inches at birth, 3.6 inches at three months, 4.0 inches at 6 months, 4.3 inches at nine months, and 4.6 inches at one year. The female means are one-tenth of an inch lower throughout. While there is a paucity of data for the second postnatal year, mean foot length is tentatively estimated as 5.1 inches for males and 5.0 inches for females at eighteen months of age, and as 5.5 inches for males and 5.4 inches for females at two years of age.

For each sex, the semiannual gains in central tendency decrease from four-fifths of an inch between birth and six months, through three-fifths of an inch between six and twelve months, to two-fifths of an inch between eighteen and twenty-four months. In percentage terms, foot length increases 43 per cent from birth to one year and around 21 per cent from one to two years. The continuity of this decreasing trend with age is seen in perspective by mention of the fact that the percentage increment from three to six prenatal months is upwards of 200 per cent and that for the successive quarter year (six prenatal months to birth) somewhat more than 50 per cent.

4. Variability in foot length is slightly smaller at birth than between six months and one year, and slightly greater for male infants than for females. These findings accrue primarily from intercomparison of the standard deviations and the coefficients of variation obtained by Bakwin and Bakwin, Goodman, and Richdorf.

Generalizing for any given age during the first postnatal year, and for both sexes combined, the foot lengths of full-term, physically normal, White infants may be taken as clustering within a range of one inch. At birth, the minimum normal value approximates 2.7 inches and the maximum value 3.6 inches. At age one year, the normal scatter is estimated to lie within the limits of 4.0 inches and 5.0 inches.

5. Measurements of foot length are available on one individual at successive ages from birth to the close of the second postnatal year. This individual (Subject 4929 from Meredith) fell at approximately the 25th percentile in pes length at birth, the 50th percentile at three months, and the 75th percentile after six months. The individual studied from one to eighteen months by Hall placed consistently between the 20th and 30th percentiles of the foot length distributions for different ages. The premature infant followed by Talbot from two weeks to seventeen months gave foot length records markedly below the zone of normal dispersion at birth, and near the lower limit of the zone at three months and at later ages. For the nine infants (excluding Subject 4929) followed by Meredith from birth to one year, four underwent shifts in percentile rank of more than 20 points. Including Subject 4929, the proportion of infants showing changes of 20 to 50 percentile points was one-half.

CHILDHOOD AND ADOLESCENCE

The earliest measurements of foot length on record for inhabitants

of North or Central America appear to be those obtained by Owen (1856) on two "so-called Aztec children" (p. 128). The measurements were made in 1853. They are mainly of historical interest.

The ages of the children were not definitely known, and there was "conflicting evidence" regarding their "birthplace and parentage" (p. 136). Pedro Velasquex, of San Salvador, Mexico, claimed "that he brought them from the Kaanat of Iximaya, an ancient city in Central America, inhabited by a remnant of the aboriginal Aztec population, and that they were the children of the Kaana priesthood" (p. 136). On the other hand, Innocente Burgos, a Mexican of Spanish origin residing in San Salvador, entered the counter claim that he was the father of the two children. Burgos gave their ages as 9 years (the male) and 7 years (the female).

The male subject had twelve permanent teeth, a stature of 87.6 cm. and a foot length of 12.7 cm. The female had seven permanent teeth, a stature of 78.1 cm. and a foot length of 11.7 cm. Both children were apparently abnormally small (*e. g.* they were smaller in foot length than typical White children at the age of two years).

Talbot (1924a) measured the foot lengths of approximately 120 "clinically normal American children" varying in age from the beginning of the third year through the tenth year. His sample was considered "not to represent exceptionally well nourished or poorly nourished children," but to typify "average children within the accepted normal limits of height and weight for age" (p. 541). It was composed of about equal numbers of males and females.

Foot length was measured on the nude foot "from the heel to the tip of the great toe" (p. 546). The measurements were "plotted on charts, and smoothed curves drawn to indicate the trend of growth" for each sex with age (p. 541). As reproduced, the trend drawn on the chart for males is estimated to pass through 15.2 cm. at three years, 17.3 cm. at five years, 19.3 cm. at seven years, and 20.6 cm. at nine years. The corresponding freehand graduation of the female data is estimated to pass through 15.8 cm. at three years, 17.4 cm. at five years, 18.8 cm. at seven years, and 20.4 cm. at nine years.

Meredith (1944) accumulated foot length data on 450 children in attendance at the University of Iowa Preschool Laboratories and Elementary School during the years 1939-44. The sample was formed by measuring all children enrolled in the Preschool Laboratories over these years, and continuing to measure those of this group who later

attended the Elementary School. With few exceptions, each child's foot length was determined within three days of his birthday. Those children available for seriatim study were remeasured at annual intervals.

The subjects (230 males and 220 females) were all residents of Iowa City and all of the White race. They were predominantly from the professional and managerial socio-economic groups, with a scattering of the commercial and skilled-trades groups. Over 90 per cent were of northwest European ancestry.

Precise measurements were obtained on the left pes, using broad-branched, sliding, aluminum calipers. The straight line distance was determined from acropodion (the most anterior tip of the hallux or second toe, whichever projects farther forward) to pternoin (the most posterior point on the heel surface). Specifically, the technique was as follows: "The subject removed shoes and stockings and assumed the erect position. The anthropometrist placed the subject's left foot on a sheet of ruled paper in such a manner that one of the ruled lines passed beneath the median plane of the second toe, anteriorly, and beneath the center of the arc of the heel, posteriorly. The subject was then directed to place his right foot alongside his left and to distribute his weight evenly through both lower limbs. A distance of about six inches was maintained between the inner aspects of the two feet. In applying the instrument, the shaft paralleled the ruled line passing beneath the second toe and pternion, the fixed branch was placed in light contact with pternion, and the movable branch was brought in light contact with acropodion." At every examination, independent measurements were made by two anthropometrists. In the event the difference between the two readings did not exceed 0.2 cm., their mean was taken. When larger differences resulted, each anthropometrist made an additional measurement and the mean of the four readings constituted the value recorded.[2]

The results from statistical analysis of the total data are given in Table 6. Selected findings from this table are:

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[2] On a series of 60 children between the ages of seven and ten years, study was made of the difference between foot length with body weight distributed "evenly through both lower limbs" and body weight sustained primarily on the right foot. For the latter condition, the subject's left foot was placed on a stool and his left leg oriented approximately at right angles to both the foot and the thigh. On the average, in this "less weighted" condition the foot was found to be shorter by 0.2 cm.

TABLE 6

Foot length (cm.) of Iowa City White children of middle and upper classes

EXACT AGE (yrs.)	N	MEAN	S. D.	V	PERCENTILES 25th	PERCENTILES 75th	RANGE
			Males				
3	47	15.6	.68	4.4	15.2	16.1	14.1 - 16.8
4	63	16.7	.74	4.5	16.2	17.2	15.0 - 18.5
5	86	17.8	.81	4.5	17.3	18.4	15.9 - 19.7
6	79	18.8	.90	4.8	18.2	19.4	16.7 - 20.9
7	68	19.7	.99	5.0	19.0	20.4	17.3 - 22.0
8	57	20.5	1.04	5.1	19.7	21.2	18.3 - 23.3
9	38	21.3	1.17	5.5	20.4	22.1	19.1 - 24.2
10	28	22.1	1.38	6.2	21.2	23.0	19.5 - 24.8
			Females				
3	43	15.4	.61	4.0	15.0	15.8	14.1 - 16.8
4	69	16.4	.69	4.2	16.0	16.9	14.6 - 18.0
5	86	17.3	.83	4.8	16.7	17.8	15.3 - 19.3
6	65	18.3	.70	3.8	17.9	18.7	16.5 - 20.3
7	48	19.4	.77	4.0	19.0	19.8	17.3 - 21.3
8	44	20.3	.85	4.2	19.8	20.8	18.3 - 22.2
9	25	21.1	.97	4.6	20.3	21.8	19.5 - 23.1
10	20	21.8	.86	3.9	21.2	22.4	20.1 - 23.6

1. Males exceed females in mean foot length at all ages from three to ten years. Although consistent in direction, the difference is small in magnitude. In general, the means for females are lower than those for males by 0.3 cm.

For both sexes combined, mean foot length increases from 15.5 cm. at three years to 22.0 cm. at ten years. The gain between three and seven years approximates 1.0 cm. per year, that between seven and ten years 0.8 cm. per year.

2. Variability in foot length is greater for males than for females. At every age except five years, the standard deviation of the male distribution is larger than that of the female distribution. Similarly, the coefficient of variation is higher for males than for females at all ages with the exception of five years.

Males show a fairly continuous increase in absolute and relative variability from age to age. The standard deviations rise from around 0.7 cm. at three years, through 1.0 cm. at seven years, to 1.4 cm. at ten years; the coefficients of variation from 4.4 per cent at three years, through 5.0 per cent at seven years, to 6.2 per cent at ten years. For females, there is a less marked and more irregular increase in absolute variability, with no clear increase in relative variability. The standard deviations approximate 0.6 cm. at three years, 0.8 cm. at seven years, and 0.9 cm. at ten years. The coefficients of variation fluctuate between 3.8 per cent and 4.8 per cent, their average value being 4.2 per cent.

3. The interquartile distance tends to become greater with age. For males, the increase is continuous and of appreciable magnitude. On the male distribution for foot length at age three years, the difference between the 25th and 75th percentiles is 0.9 cm., on the male distribution at age ten years it is twice this amount. For females, the interquartile distance fluctuates in size from age to age, with only a slight tendency to increase. Over the age period from three to seven years, the central one-half of the female measurements lie within an average zone of 0.9 cm.; for the years seven to ten, the average zone is about 1.2 cm.

4. The distance between the minimum and maximum values of the male distributions becomes wider with age. At three years the difference is 2.7 cm., at five years 3.8 cm., at seven years 4.7 cm., and at ten years 5.3 cm. The distance between the minimum and maximum values of the female distribution is identical with that for males at three years, and hovers near 3.7 cm. at all ages from four to ten years.

5. There is considerable overlapping of the distributions for successive ages. The upper one-fourth of the male distribution at age five years has the same limits as the lower one-fourth of the male distribution at age eight years. Turning to the female distributions, the highest value at age three years is similar to the lowest value at age six years, likewise the highest value at age six years approximates the lowest value at age ten years.

As already indicated, some of the 450 subjects were examined once only, others twice, and still others several times. Protocols covering four to five consecutive years were obtained on 53 of the subjects. This series—consisting of 30 males and 23 females—represents individuals enrolled in the study during 1939 or 1940, and examined annually without interruption to 1944 (see Table 7).

TABLE 7

Longitudinal data for foot length (cm.) on 53 White, private school children residing in Iowa City, Iowa

SUBJECT	AGE IN YEARS 3	4	5	6	7	8	9	10	11
				Males					
1908	15.7	17.0	18.0	18.8	19.5	....	....	....	....
6134	16.2	17.5	18.7	19.7	20.7	....	....	....	....
7291	16.7	17.6	18.5	19.3	20.1	....	....	....	....
8071	15.9	17.0	18.0	18.9	19.7	....	....	....	....
4438	....	15.7	16.6	17.4	18.2	19.0	....	....	....
4716	....	16.9	17.9	19.0	20.0	20.9	....	....	....
6799	....	16.7	17.7	18.4	19.1	19.8	....	....	....
130	....	....	18.1	19.0	19.9	20.8	21.7	....	....
216	....	....	19.7	20.6	21.5	22.4	23.0	....	....
2755	....	....	17.8	18.8	19.6	20.4	21.2	....	....
3057	....	....	18.6	19.6	20.4	21.2	22.0	....	....
3630	....	....	17.5	18.2	19.2	20.1	21.0	....	....
4277	....	....	17.2	17.9	18.8	19.6	20.4	....	....
4619	....	....	19.8	21.0	22.1	23.4	24.5	....	....
6003	....	....	18.2	19.2	20.0	20.9	21.6	....	....
7056	....	....	18.0	19.1	20.1	21.0	21.8	....	....
9038	....	....	18.4	19.3	20.4	21.5	22.6	....	....
1149	....	....	18.0	19.1	20.0	21.1	22.0	22.8	....
2187	....	....	18.5	19.7	20.9	21.8	22.8	23.8	....
3018	....	....	17.6	18.6	19.6	20.5	21.2	21.8	....
425	....	....	....	18.0	18.7	19.7	20.6	21.5	....
724	....	....	....	18.0	18.7	19.5	20.2	21.1	....
1124	....	....	....	17.2	18.0	18.7	19.2	19.7	....
3572	....	....	....	18.8	19.8	20.9	21.9	22.8	....
4397	....	....	....	16.5	17.5	18.5	19.4	20.0	....
5327	....	....	....	18.6	19.6	20.7	21.6	22.3	....
7095	....	....	....	19.6	20.3	21.2	22.1	22.9	....
4938	....	....	....	19.6	20.8	22.0	23.0	23.6	24.2
2817	....	....	....	....	20.0	20.7	21.6	22.5	23.4
7096	....	....	....	....	20.1	21.1	22.0	22.7	23.4
				Females					
4746	15.0	16.0	16.9	17.7	18.6	....	....	....	....
1013	15.1	16.7	17.8	18.6	19.3	20.1	....	....	....
1157	15.3	16.8	18.0	18.8	19.6	20.5	....	....	....
424	....	15.9	17.0	18.0	18.8	19.6	....	....	....

2049	....	16.1	17.2	18.3	19.2	20.1	....	....	....
2333	....	16.3	17.3	18.3	19.3	20.3	....	....	....
4224	....	17.5	18.4	19.4	20.5	21.5	....	....	....
383	....	....	16.8	17.6	18.5	19.3	20.1	....	....
4749	....	....	17.7	18.6	19.6	20.6	21.5	....	....
4937	....	....	19.0	20.3	21.3	22.2	22.8	....	....
5413	....	....	18.2	19.2	20.2	21.2	22.2	....	....
211	....	....	....	18.5	19.4	20.2	21.0	21.7	....
2178	....	....	....	19.2	20.2	21.2	22.2	23.2	....
393	....	....	....	18.3	19.3	20.3	21.2	22.1	22.8
2147	....	....	....	18.6	19.7	20.8	21.6	22.4	23.3
2318	....	....	....	18.9	19.8	20.8	21.5	22.2	22.8
7732	....	....	....	18.1	18.8	19.4	20.0	20.7	21.4
753	....	....	....	....	19.8	20.7	21.4	22.2	23.0
2678	....	....	....	....	19.7	20.6	21.6	22.4	23.2
4398	....	....	....	....	17.8	18.8	19.5	20.1	20.6
6207	....	....	....	....	19.2	20.1	20.9	21.6	22.1
7535	....	....	....	....	19.7	20.4	21.1	21.7	22.6
8883	....	....	....	....	18.9	19.8	20.6	21.4	22.1

Intercomparison among the 30 males in Table 7 shows:

1. The foot lengths of Subjects 1908 and 8071 were practically identical at all ages between three years and seven years. A like finding holds for Subjects 7056 and 1149 over the age interval from five to nine years, and for Subjects 130 and 6003 over the same age period.

2. Compared with Subject 6134, Subject 7291 had a foot 0.5 cm. longer at three years of age, 0.2 cm. shorter at five years, and 0.6 cm. shorter at seven years. It follows that the gain in foot length between three and seven years was 1.1 cm. greater for Subject 6134 than for Subject 7291. In a parallel manner, between ages six and ten years Subject 4397 gained 1.0 cm. more in foot length than Subject 1124, the former having the shorter foot by 0.7 cm. at six years and the longer foot by 0.3 cm. at ten years.

3. The foot length trends for Subjects 216 and 2187 converge from a difference of 1.2 cm. at five years to a difference of 0.2 cm. at nine years. The same relationship obtains for the records on Subjects 3572 and 7095, the convergence being from a difference of 0.8 cm. at six years to no appreciable difference at ten years.

4. On Subjects 4716 and 6799 the growth curves for foot length lie within 0.2 cm. of coinciding at four years and are 1.1 cm. apart at eight years. The curves on Subjects 216 and 4619 show similar

divergence. These are practically superimposed at five years, while at nine years the former lies 1.5 cm. below the latter.

Similarly, for the females in Table 7, intercomparison shows:

1. The foot lengths of Subjects 2049 and 2333 were practically identical at each successive age from four years to eight years. The same finding accrues for Subjects 753 and 2678 between ages seven and eleven years.

2. Subject 4746 had a shorter foot than Subject 1157 by 0.3 cm. at three years and by 1.0 cm. at seven years. More marked divergence in foot length with age occurred for Subjects 393 and 7732. The latter exceeded the former by 0.2 cm. at six years, by 0.9 cm. at eight years, and by 1.4 cm. at ten years.

3. Over comparable four-year periods, individual differences in amount of growth in foot length tend to be less marked for females than for males. On the four females studied from five to nine years, the gains fall between 3.3 cm. (Subject 383) and 4.0 cm. (Subject 5413). On the ten females with measurements at seven and eleven years, the variation in gain is from 2.6 cm. (Subject 7732) to 3.6 cm. (Subject 2147).

Davenport (1932) analyzed data for foot length representing consecutive annual ages from five to sixteen years. Separate analyses were made covering a series of male records accumulated at Letchworth Village, Thiells, New York, and series of measurements on males and females amassed at the Orphan Asylum of Brooklyn, New York. Description of the subjects was limited to the following: "something over 100 boys and 50 girls in the Orphan Asylum of Brooklyn . . . mostly of North European origin"; "about 100 idiot boys and 120 high-grade boys at Letchworth Village . . . including various European stocks and a few 'American Negroes,' mostly rather dark in complexion" (p. 174). Many of the subjects were "measured repeatedly."

The measurements were obtained by four similarly trained anthropometrists. "The subject was always standing on both feet, and the right foot was usually measured. In most of the work an outline of the foot was traced on paper with a split pencil held strictly vertical . . . In other cases the foot was measured directly" (p. 174). Foot length was taken as "the greatest distance from the back of the heel outline to the tip of the second toe" (p. 175).[3]

[3] On a sample of 75 tracings Davenport found the most forward projection of the second toe to be exceeded by that of the hallux in 70 instances (93.3 per cent).

TABLE 8

Mean foot length (cm.) of children at two New York institutions

AGE	ORPHAN ASYLUM OF BROOKLYN		"LETCHWORTH VILLAGE"
(yrs.)	Males	Females	Males
5	16.5	16.1	
6	17.1	17.1	17.5
7	17.8	18.1	18.5
8	18.7	18.7	19.3
9	19.6	19.5	19.6
10	20.7	20.5	20.2
11	21.7	21.3	21.1
12	22.3	21.6	21.2
13	23.3	22.5	22.1
14	23.9	23.2	22.5
15	25.0	22.9	23.4
16	25.7	23.0	23.9

Mean values obtained from statistical reduction are reproduced in Table 8. The means on children of the Brooklyn Orphan Asylum register no consistent sex difference over the age interval from five to ten years. From the twelfth year on, the male values clearly exceed the female values, their differences widening from 0.7 cm. at twelve years to 2.7 cm. at sixteen years. Compared with the means on "Letchworth Village" males, the means on the orphanage males are somewhat smaller at ages below nine years, and become increasingly larger between ten and sixteen years.

Individual growth curves were included for three of the "Letchworth Village" subjects.

Seriatim records for foot length (cm.) on three "Letchworth Village" males

	AGE IN YEARS									
SUBJECT	8	9	10	11	12	13	14	14.7	14.8	15.0
8	17.5	18.6	19.2	20.6	21.2	21.6	23.2	24.3	....	....
28	17.0	17.5	18.1	18.8	19.9	20.5	21.1	....	21.6	....
66	19.2	19.5	19.9	20.2	20.8	21.6	22.9	....	....	23.9

Subject 28 had a shorter foot than Subject 8 at all ages from eight to fifteen years. Compared with Subject 66, the foot length of Subject 8 was appreciably shorter between eight and ten years and slightly longer at fourteen and fifteen years. Subject 66 gained only 1.0 cm. between eight and eleven years, and three times this amount between twelve and fifteen years. The gains for Subjects 8 and 28 were not appreciably different over these two age intervals. The former, however, made larger gains than the latter in both periods.

Central tendency values for pes length were reported by Hall (1896) on upwards of a thousand "school boys" considered "homogeneous as to race, nationality, sex, social condition and physical development" (p. 27). The subjects ranged in age from nine to seventeen and were in attendance around 1890 at three private schools in or near Philadelphia—"the William Penn Charter School, the Haverford Grammar School, and the Wilmington Friends' School" (p. 21). "Their parents were almost without exception born in America, and the families came originally from England. The families were with very few exceptions well-to-do" (p. 21). The "exceptional opportunities" which all three institutions offered for physical development "induced a great majority of the students and pupils to enter actively into athletics" (p. 21).

Length of the nude pes was measured with wooden calipers "from the posterior surface of the calcaneum to the tip of the first or second digit" (p. 25). The measurements were made "under the most favorable circumstances" and taken with great care.

Foot length medians (cm.) on private school boys measured about 1890

	MIDPOINT OF AGE GROUP *(yrs.)*							
	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
Number	93	122	132	143	203	209	233	284
Median	19.7	21.0	21.7	22.5	23.9	24.5	25.5	25.9

Interpolated values at consecutive yearly intervals from ten to sixteen are: 20.3 cm., 21.3 cm., 22.1 cm., 23.2 cm., 24.2 cm., 25.0 cm., and 25.7 cm. The value at ten years is 1.8 cm. below the mean obtained by Meredith on boys of like age and socio-economic level examined 1943-

44. This difference is of sufficient magnitude to suggest there may have been a secular trend in the direction of increased foot length over the last half century.[4]

Compared with the means from Davenport on males of the Orphan Asylum of Brooklyn, Hall's values are slightly lower at ten and eleven years, similar between twelve and fourteen years, and identical at fifteen and sixteen years. Davenport's means would probably have been higher than Hall's at all ages had both investigators used the same anthropometric landmarks. Secularly, Davenport's data were collected thirty to forty years after Hall's and ten to twenty years before Meredith's; socio-economically, the studies of Hall and Meredith were on private school children and that of Davenport on children in an orphanage.

Moon (1896) described distributions of male foot length for each year of age from the twelfth to the seventeenth. The data used in compiling the distributions were accumulated over an eight-year period from annual measurement of "each boy of the McDonogh School, situated near Baltimore, Md." (p. 3).

TABLE 9

Foot length (cm.) of boys attending the McDonogh School, Maryland, around 1890

AGE GROUP Midpoint	Range (yrs.)	N	FOOT	PERCENTILES 5	10	25	50	75	90	95
11.5	11 - 12	100	Right	20.3	20.6	21.1	21.8	22.7	23.3	23.6
			Left	20.2	20.5	21.1	21.9	22.8	23.5	23.6
12.5	12 - 13	120	Right	21.0	21.3	21.9	22.8	23.5	24.3	24.5
			Left	20.9	21.3	22.0	22.8	23.6	24.1	24.4
13.5	13 - 14	115	Right	21.5	22.0	22.5	23.0	24.0	24.9	25.2
			Left	21.4	21.9	22.5	23.2	24.1	25.0	25.2
14.5	14 - 15	150	Right	22.0	22.4	23.2	23.8	24.9	26.0	26.5
			Left	22.1	22.5	23.2	23.9	25.0	26.2	26.6
15.5	15 - 16	150	Right	22.4	23.1	23.8	24.8	25.8	26.7	27.3
			Left	22.5	23.3	24.0	25.0	25.7	26.9	27.4
16.5	16 - 17	130	Right	23.4	23.8	24.4	25.3	26.0	27.0	27.2
			Left	23.5	23.8	24.4	25.3	26.1	26.9	27.3

[4] In this connection, it is pertinent to mention that at all elementary school ages a marked increase in stature over the past half century has been unequivocally demonstrated. See, for instance, HUMAN BIOL., 1944, 16, 126-131.

There was no discussion of the anthropometric technique employed. For the right and left feet separately, percentiles were reported at five-unit intervals from the 5th to the 95th. Of these nineteen columns of percentiles, it will suffice to reproduce seven (see Table 9). Table 9 yields:

1. No consistent, systematic difference between the distributions for length of the right foot and those for length of the left. Over the age period from eleven to fourteen years, six of the percentile values on each foot are equal, seven are slightly greater on the right, and eight slightly greater on the left. For the other half of the age span studied, there are three pairs of equivalent values, two instances in which the figures on the right pes are the higher, and sixteen instances in which the left pes exceeds the right.

2. An average increase in median foot length during the five-year period covered of approximately 0.7 cm. per year. At the lower end of the distributions (5th and 10th percentiles) the increase averages slightly less than 0.7 cm. per year, and at the upper end of the distributions (90th and 95th percentiles) slightly more than this amount.

3. An average interquartile distance (75th percentile minus 25th percentile) of 1.7 cm., and an average zone encompassing the central eighty per cent of the measures in each distribution (90th percentile minus 10th percentile) of 3.2 cm. In both cases, the limits of dispersion are slightly wider for the fifteenth and sixteenth years than at other ages.

Records for foot length on "twelve hundred girls and boys from the student class" were accumulated by Sargent (1889). The subjects ranged in age from thirteen to seventeen years, and gave a mean age of fifteen years. They were probably drawn from schools in the vicinity of Cambridge, Massachusetts. The female subjects were reported to have yielded an average foot length lower than that from the male subjects "by over half an inch" (p. 176).

Data were reported by Hrdlička (1926) on three albino Indians "from the San Blas Territory, Panama" (p. 8). The approximate ages of these subjects were ten (male), fifteen (female), and seventeen years (male). They were brought to Washington, D. C., by Mr. R. O. Marsh and measured by Hrdlička in 1924. Their records for length of the left foot were 21.8 cm., 23.5 cm. and 23.2 cm. respectively.

Williams (1939) obtained measurements of foot length on 192 Negro boys between the ages of fourteen years six months and nine-

teen years six months (Table 10). The boys were in attendance during 1938-39 at the Booker T. Washington High School, Tulsa, Oklahoma. Anthropometric procedure: After removal of his shoes

TABLE 10

Foot length (cm.) of Negro males measured at Tulsa 1938-39

Midpoint	AGE GROUP Range (yrs.)	N	MEAN	S. D.	V	PERCENTILES 10th	PERCENTILES 90th	RANGE
15	14.5 - 15.5	25	27.1	.....	....	....	....	....
16.5	15.5 - 17.5	100	27.1	....	....	....	....	....
18.5	17.5 - 19.5	67	27.5	....	....	....	....	....
Total sample		192	27.2	1.35	5.0	25.6	28.9	24.0 - 31.5

and socks, each subject was requested to stand upon a table. "The right foot was then placed upon a sheet of paper and the left foot placed about three inches behind the right and four inches to the left. The weight of the body was distributed mainly through the left leg, and the right knee was slightly flexed so that the right leg was perpendicular to the top of the table" (p 3). A tracing was made indicating the most posterior protrusion of the subject's heel and the tip of "the toe projecting the farthest forward (with but two exceptions, this was the great toe)" (p. 3). Foot length was measured on the tracings. The mean at 16.5 years is higher than the corresponding central tendency values for White males from Hall and Moon by 1.2 cm. and 1.8 cm., respectively. Williams' smallest Negro record of 24.0 cm. exceeds the 10th percentile of the Moon distribution for the seventeenth year.

In presenting a synthesis of the nine foregoing studies on growth in foot length during childhood and adolescence, the procedure will be that of asking leading questions and indicating the extent to which the accessible materials serve to answer them. It will be advantageous to treat the age periods three to ten years and ten to sixteen years separately. Consideration will be given first to the earlier period.

1. What is the typical foot length (distance from pternion to acropodion) of three-year-old White residents of North America? How

long is the typical human foot at ages six and nine years? A pooling of the data on both sexes from the studies of Davenport (New York)[5], Meredith (Iowa) and Talbot (Massachusetts) affords composite averages of 6.0 inches at three years, 7.1 inches at six years, and 8.1 inches at nine years. The composite averages at four, seven, and ten years are 6.5 inches, 7.5 inches and 8.5 inches, respectively. It follows that over the seven-year period from three to ten years foot length increases 2.5 inches or slightly more than 40 per cent.

2. How does average foot length at specified childhood ages compare with average foot length at selected fetal and infancy ages? Is the rate of increase in central tendency higher in early childhood than in later childhood? Average foot length at three postnatal years is three times that at six prenatal months; average foot length at four years, twice that at birth; and average foot length at five years, one and one-half times that at one year. In the typical White child foot length apparently increases over 18 per cent between three and six years, and less than 13 per cent between seven and ten years.

3. Are there racial, socio-economic, secular, or sex differences in foot length during childhood? Throughout the age period from three to ten years, Meredith found males to exceed females in mean foot length by approximately one-tenth of an inch. Davenport, on the other hand, found both sexes to have "feet of about the same length . . . between the ages of six and nine years" (p. 177). For ages five to ten years, the means reported by Meredith on private school children are higher by about 1.5 cm. than those reported by Davenport on orphanage children studied more than a decade earlier. After allowance is made for the lack of comparability of these studies in anthropometric technique, there remains a reduced difference in central tendency which may be due to the differences in socio-economic and/or secular sampling. The extent to which there are differences in foot length during childhood between North American inhabitants of Negroid or Indian ancestry and those of White ancestry is not substantially known. Without supplying quantitative evidence, Davenport has stated that the typical Negro child of nine and ten years "has a longer foot than the child of North European stock" (p. 179).

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[5] These data were adjusted to approximate the distance from pternion to acropodion.

The need for further investigation of the problems encompassed in this paragraph is obvious.

4. How wide are individual differences in foot length at various childhood ages? Is one sex more variable than the other? What is the range of normal dispersion at three years? Does this range change appreciably between three and ten years? Answers to these questions are available only in terms of a single study utilizing private school children principally of northwest European ancestry. Males were found to be slightly more variable than females. For both sexes combined, one-half of the children aged three years had foot lengths falling within a zone one-quarter inch above and below the mean. The full range of the distribution was slightly over one inch. Between three and ten years, the interquartile distance widened from half an inch to three-fourths of an inch, and the range from slightly more than one inch to slightly more than two inches.

5. Do some individuals have long feet in early childhood and short feet in later childhood, or vice versa? More generally, to what extent do children change their positions in the distribution of foot length from age to age? Meredith has followed 47 children over four or five consecutive years between the ages of three and ten. For the 14 children studied from ages three or four years to seven or eight years, six (43 per cent) underwent changes in percentile rank of twenty to fifty points. Of the remaining 33 children studied between ages five or six years and nine or ten years only three (9 per cent) varied in percentile rank as much as twenty points. While no children have yet been followed for the whole seven-year period from three to ten, it appears reasonable to infer that rarely, if at all, will a child's foot length be found to fall in the upper one-fourth of the distribution at three years and in the lower one-fourth of the distribution at ten years, or vice versa.

The accessible research materials for the period ten to sixteen years are those of Hall, Moon and Williams on males and of Davenport and Sargent on both sexes.

1. Is the average foot length of males greater than that of females during the years from ten to sixteen? If so, what is the magitude of the difference at various ages? Davenport found that between ten and sixteen years "the feet grow in length, on the average, slower in girls than in boys" (p. 178). His foot length means on children of the Orphan Asylum of Brooklyn show males to exceed females by one-tenth of an inch at ten years, three-tenths of an inch at thirteen years,

and one inch at sixteen years. Sargent, writing four decades earlier, claimed to have studied a large series of individuals around fifteen years of age drawn from a higher socio-economic level, and to have obtained a mean foot length on the males greater than that on the females "by over half an inch".

2. Does the foot length of the typical White adolescent differ from that of the typical Negro adolescent? Information on this question is available for males only. Combining the findings on White males from Davenport, Hall, and Moon, mean foot length (from pternion to acropodion) approximates 8.9 inches at twelve years, 9.5 inches at fourteen years, and 10 inches at sixteen years. Williams' study on Negro males yields a mean foot length at sixteen years of 10.7 inches. In evaluating this difference, it must not be overlooked that the mean at sixteen for White males represents a somewhat earlier secular period than that for Negro males. (Parenthetically, a fruitful study of secular change in foot length during the adolescent years could be made by utilizing the substantial findings of Hall and Moon representing 1890 and obtaining comparable samples representing the present decade).

3. Is there any change in variability of foot length over the adolescent years? Davenport has reported that for males variability in foot length is "highest from twelve to fifteen years" (p. 176). Unfortunately, he omitted presentation of his variability values. Moon found male dispersion to be slightly greater at 14.5 and 15.5 years than at earlier and later ages. In general, at each age from twelve to sixteen years, the middle one-half of Moon's measurements fell within a zone approximating three-fourths of an inch. The zones delimiting eighty per cent of each distribution (90th percentile minus 10th percentile) were around 1.3 inches at thirteen and sixteen years and 1.5 inches at fifteen years.

EARLY ADULTHOOD: FEMALES

Hitchcock (1891) reported the average length of each foot for young women attending two New England colleges between 1884 and 1889. The subjects numbered "about five hundred individuals each at . . . Mt. Holyoke and Wellesley Colleges" (p. 38). They represented five successive freshmen classes.

The method of measuring foot length was not discussed. Seemingly, the data were supplied by "Dr. Cotton" of Mt. Holyoke and "Misses

Hill and Wood" of Wellesley. "Mr. Frank A. Delabarre" made the statistical analysis.

Average foot length (cm.) of women attending two New England colleges 1884-89

N	RIGHT FOOT	LEFT FOOT
c.1000	22.9	22.9

It will be seen that identical averages were obtained on the right and left feet.

Shortly after the appearance of Hitchcock's paper, a more extensive study of foot length on women attending Wellesley College was published by Wood (1893). The subjects totaled 1,500 students. Attention was given to both central tendency and variability.

Foot length (cm.) of women attending Wellesley College prior to 1893

FOOT	MINIMUM VALUE	PERCENTILES: 5	10	25	50	75	90	95	MAXIMUM VALUE
Right	21.2	22.1	22.4	23.1	23.8	24.6	25.1	25.7	26.5
Left	21.1	22.1	22.3	23.0	23.7	24.5	25.0	25.6	26.4

For each foot, the interquartile distance is 1.5 cm. and the range 5.3 cm.

Hanna (1894) collected data for right and left pes length on 1,600 female students attending Oberlin College, Ohio. Statistical reduction of the data gave the following tabulation.

Foot length (cm.) of women attending Oberlin College prior to 1894

FOOT	MINIMUM VALUE	PERCENTILES: 5	10	25	50	75	90	95	MAXIMUM VALUE
Right	20.7	21.5	21.9	22.5	23.2	23.9	24.6	24.9	25.8
Left	20.7	21.5	21.8	22.5	23.2	23.9	24.4	24.9	25.8

Corresponding percentiles are largely identical on each pes. The average lies between those obtained by Hitchcock and by Wood. The interpercentile distances are practically the same as from Wood.

Clapp (1899) compiled an anthropometric table based on data accumulated at the University of Nebraska. Her subjects were 1,500 women students. The table afforded foot length means for each centimeter of stature "from 149 cm. to 173 cm.". Mean foot length without regard to stature is estimated to have approximated 23.5 cm.

Analyses of foot length were made by Bowles (1932) on 364 selected subjects attending two eastern women's colleges in the period from around 1880 to 1910. The subjects were predominantly from New England families of northwest European descent. When measured, they were students either at Vassar or Wellesley. Every subject included later had a daughter who attended the same college as her mother.

Foot length (cm.) on selected samples of college women

SOURCE	MEAN AGE (yrs.)	N	MEAN	S. D.	V	RANGE
Wellesley	19.5	165	23.4	1.12	4.8	19.5 - 26.0
Vassar	18.0	199	23.3	1.05	4.5	20.5 - 26.5
Both colleges	18.7	364	23.3	1.08	4.6	19.5 - 26.5

Compared with the central tendency values from the studies of Hitchcock and Wood, Bowles' means are intermediate. The range obtained by Bowles on his total sample (7.0 cm.) is appreciably wider than the ranges from Wood (5.3 cm.) and Hanna (5.1 cm.).

Measurements of pes length taken on 100 Smith College students were analyzed by Wilder and Pfeiffer (1924). The subjects were "mainly British in origin" and "in every case their ancestry was derived from the nations of western Europe" (pp. 444, 453).

For a description of the anthropometric technique employed, the reader was referred to an earlier publication by Wilder. Here, it was stated that length of the left pes was taken "burdened by weight of body". The subject stood upon an "osteometric board" (p. 162). Acropodion was placed in contact with the fixed upright of the instrument, and the moveable upright was brought into contact with pternion. The measurements were made around 1920 by Pfeiffer.

Foot length (cm.) on women attending Smith College about 1920

AGE GROUP						PERCENTILES		
Mean *(yrs.)*	Range	N	MEAN	S. D.	V	25th	75th	RANGE
20.4	17 - 27	100	24.1	1.13	4.7	23.3	24.9	20.7 - 27.3

These figures for the 25th percentile, the mean, and the 75th percentile, representing the termination of the second decade of postnatal life, are higher than the corresponding statistics from Meredith for the end of the first decade by 2.1 cm., 2.3 cm. and 2.5 cm., respectively.

Patek (1926) made measurements of foot length on "150 women, chosen at random, from the Stanford University gymnasium classes" (p. 277). Her subjects "belonged mainly in the freshman and sophomore years" (p. 277). They ranged in age from sixteen to twenty-seven years, two being younger than seventeen and seven older than twenty-one. Their mean age was 18.9 years.

Foot length was determined, by means of a specially constructed pedometer, "while the person was seated and also while standing on one foot" (p. 277). Both feet were measured in each position (Table 11). In the sitting position, the feet rested on the base of the pedo-

TABLE 11

Foot length (cm.) on 150 undergraduate women of Stanford University

FOOT	MEAN	S. D.	V	PERCENTILES				RANGE
				10th	25th	75th	90th	
				Subject seated				
Left	23.6	1.10	4.7	22.3	22.9	24.3	25.1	19.9 - 26.5
Right	23.7	1.09	4.6	22.3	22.9	24.3	25.1	20.0 - 26.3
				Subject standing on one foot				
Left	24.0	1.09	4.5	22.7	23.3	24.8	25.5	20.3 - 26.6
Right	24.0	1.12	4.7	22.6	23.2	24.7	25.5	20.2 - 26.6

meter. In the position "standing on one foot", the subjects were "permitted to balance themselves slightly by means of the back of a chair

if necessary" (p. 277). Apparently, foot length was taken from acropodion to pternion. The magnitude of the difference in mean foot length for these two positions is in harmony with the smaller difference for two other positions (0.2 cm.) obtained by Meredith on children seven to ten years of age. Patek's sitting position appears roughly comparable with Meredith's orientation of the subject's foot on a stool, while Patek's orientation with the subject standing solely on the foot being measured represents a more extreme "weighting" than Meredith's position with the body weight distributed evenly through both lower limbs.

Carter (1932) reported an analysis of foot length data taken on 108 "Old American" women students attending Pembroke College, Rhode Island, in 1927. Besides being "individuals whose parents and four grandparents were born in the United States" (p. 497), the subjects were "mainly from New England" and predominantly of English ancestry. It follows that the sample was highly homogeneous ethnically, geographically, secularly, and culturally.

The data were collected by "Miss Alice M. Tousley . . . who received her training under Dr. Aleš Hrdlička" (p. 497). Consequently, they may be assumed to represent measurements of the left foot, from acropodion to pternion, with the foot resting on a stool.

Foot length (cm.) on 'Old American' women at Pembroke College 1927

AGE GROUP						PERCENTILES		APPROX.
Mean	Range (yrs.)	N	MEAN	S. D.	V	25th	75th	RANGE
19.3	16 - 25	108	24.0	1.14	4.8	23.3	24.8	21.2 - 27.6

The entire findings practically coincide with those of Wilder and Pfeiffer on young women enrolled at Smith College around 1920.

Steggerda, Crane and Steele (1929) reported a study of foot length records amassed from measurement of 100 women attending Smith College during the academic year 1928-29. The subjects were "volunteers" recruited through announcement of the project in classes of the Department of Zoology. All were born in the United States; 74 per cent were residents of New England and Middle Atlantic States, 14 per cent of Middle Western States, and the remaining 12 per cent of

Southern and Far Western States. "The racial stock of the subjects were predominantly British, those of German stock ranked second, and nearly all claimed Western Europe as the home of their ancestors" (p. 190).

For each subject, a "drawing of the right foot" was made with "the shoes alone being removed" (p. 191). The measurement of foot length was taken on this "outline of the stockinged foot" as "the maximum distance from the great toe to the heel" (pp. 200, 236).

Foot length (cm.) of women attending Smith College 1928-29

AGE GROUP						PERCENTILES	
Mean (yrs.)	Range	N	MEAN	S. D.	V	25th	75th
20.2	17 thru 24	100	23.7	1.09	4.6	22.9	24.5

The values for the measures of dispersion (standard deviation, coefficient of variation, and interquartile distance) are in close agreement with those secured by Wood at Wellesley, Hanna at Oberlin, Bowles at Vassar, and Patek at Stanford.

During 1930-32, measurements of foot length were made by Gould (1936) on "200 young women" of "Old American stock" and "Old Southern" residence (p. 62). The subjects were 172 undergraduates in attendance at "Newcomb College of Tulane University, New Orleans," 12 alumni and 16 "others, younger faculty or relatives or friends of students" (p. 58). Their homes were predominantly in Louisiana and Mississippi, with over 85 per cent in "states bordering the Gulf of Mexico" (p. 60). Almost without exception, their ancestors were "from the British Isles, France, and Germany," having settled in North America "no more recently than the great-grandparental generation" (p. 62). Over 70 per cent had "four to eight great-grandparents born south of the Mason and Dixon's line" (p. 58). In addition to rejection of individuals not of northwest European descent and longstanding family residence in the southern part of the United States, "no persons having obvious physical defects or endocrine disorders" were accepted (p. 59).

Seven per cent of the subjects were under seventeen years of age, 85 per cent between seventeen and twenty-three years, and 8 per cent

between twenty-three and thirty-eight years. "The anthropometric technique was that acquired under Doctor Hrdlička's personal instruction" (p. 64). It may be inferred that (a) each subject was instructed to raise her left foot and rest it on a stool or bench, and (b) the length of this foot was measured from pternion to acropodion.

Foot length (cm.) on 'Old American' women at Newcomb College, Louisiana

AGE GROUP						PERCENTILES				APPROXIMATE
Mean (yrs.)	Range	N	MEAN	S. D.	V	10th	25th	75th	90th	RANGE
19.9	15 - 38	200	23.6	.98	4.1	22.3	22.9	24.3	24.8	21.5 - 26.4

Additional means were reported on two ethnic subgroups drawn from among the total series. For 71 individuals "whose ancestors practically all appeared to have come from the British Isles," mean foot length was 23.8 cm. (p. 63). For 46 "young women with one-fourth or more of French ancestry in the great-grandparental generation" (a mixed group representing "about 41 per cent of French ancestry" p. 53), mean foot length was 23.5 cm. (p. 75).

Records for length of the left pes were obtained by Hatlestad (1940) on 200 White women enrolled in physical education classes at the Kansas State Teachers College of Pittsburg during the fall semester of 1938. The measurements were taken from pternion to the tip of the hallux, with the subject's body weight evenly distributed through the lower limbs.

Foot length (cm.) of college women measured at Pittsburg, Kansas, 1938

AGE GROUP						PERCENTILES				
Midpoint (yrs.)	Range	N	MEAN	S. D.	V	10th	25th	75th	90th	RANGE
19	17 - 21	200	24.0	1.18	4.9	22.5	23.2	24.7	25.5	20.7 - 27.1

These findings are similar throughout to those secured by Wilder and Pfeiffer at Smith College and by Carter at Pembroke College. They are higher for central tendency and variability than those of Gould at Newcomb College.

Beall (1939) collected and analyzed 383 measurements of pes length as part of "an effort to determine whether there is any relationship between various structural anthropometric measurements of selected college women and their success in basketball, swimming, tennis, and the modern dance" (p. 47). The subjects were 346 sophomore and junior students examined in the spring of 1938 "at five eastern women's colleges, namely, Barnard, Goucher, Vassar, Smith, and Wellesley" (p. 6). All were "White, born of American-born parents, and not restricted by the college physician as to type of physical activity they could take" (p. 7). "The five colleges selected were chosen because their proximity to New York made it possible for one person to take all measurements; because they are liberal arts colleges drawing from families with much the same socio-economic background; because they offer similar programs of physical education . . . sophomores and juniors were used in preference to freshmen in order to obtain students eighteen years of age or over and thus minimize the possibility of incomplete structural growth" (p. 6).

The subjects were selected in terms of degree of skill in the four activities. For each activity, the instructors at each college designated from among those having "at least two seasons of experience in the activity" the 10 per cent considered most skillful and the 10 per cent "poorest in skill" (pp. 7-11). In the modern dance, the basis of selection was "skill in execution of dance movements rather than of creative ability. Speed and endurance rather than diving ability were the criteria for swimming" (p. 8).

Length of the right pes was measured from acropodion to pternion. The instrument used was an anthropometer "converted into a rod compass, or large form of slide compass" (p. 20). "Thin socks were worn" (p. 23). Each subject "stood on a table with feet parallel and about six inches apart, weight evenly distributed" (p. 25). "The slide compass was held horizontally by the observer, standing on the right side of the subject with the fixed arm in contact with pternion. The moveable arm was brought lightly to the acropodion" (pp. 25-26). Reliability was studied by taking measurements "twice" on each of 35 students in attendance at Columbia University. Correlation of the two sets of values gave a reliability coefficient (Pearson product-moment) of .997. For all four activities together, mean foot length was 24.0 cm. on those showing the "greatest amount of skill" and on those "poorest in skill". The means for all subgroups are shown in Table 12.

TABLE 12

Foot length (cm.) of college women rated "skilful" and "unskilful" in selected physical activities

ACTIVITY	UPPER 10% IN SKILL			LOWER 10% IN SKILL		
	N	Mean Foot Length	Mean Stature	N	Mean Foot Length	Mean Stature
Basketball	55	24.3	167.4	41	23.9	165.6
Swimming	45	24.2	166.1	29	23.8	164.7
Tennis	75	23.9	165.7	65	24.0	163.8
Modern dance	44	23.9	164.9	29	24.2	166.3

The foot length of Negro college women was studied by Steggerda and Petty (1940) at the Tuskegee Institute, Alabama. "One hundred girls from the physical education classes at the college were selected at random by Mrs. C. E. Petty and were measured by M. Steggerda" (pp. 110-111). While they were "selected so as to eliminate all obvious Negro-White hybrids, . . . nearly every girl measured told of some degree of White and Indian admixture." It was estimated that the hundred girls each had more Negro blood than White and Indian blood together. "Thus the Negro population are at least 50 per cent Negro and very likely as much as 75 per cent Negro; there may be some 80 and 85 per cent pure Negro. The authors feel confident that in no case are any of the subjects 100 per cent Negro" (p. 111).

Tracings were made of the right stockinged foot of each subject and these tracings measured from the projected "tip of the great toe to the most posterior point of the heel."

Foot length (cm.) of Negro college women at Tuskegee Institute, Alabama

AGE GROUP				
Mean (yrs.)	Range	N	MEAN FOOT LENGTH	MEAN STATURE
20.1	17 thru 24	100	25.0	163.3

Comparison was made between the distribution of foot length from this sample of Negroes and that from the Smith College Whites studied

by Steggerda, Crane and Steele. A statistically significant difference was obtained, the Negroes having the longer foot.

To his materials on foot length in White and Negro college women, Steggerda (1940) added a study for Indian women of college age. Measurements were taken on "100 young Navajo women, mostly from the government schools at Albuquerque and Ft. Wingate, New Mexico" (p. 417). "Any Navajos who were aware of White, Negro or other Indian admixture were excluded from the study" (p. 418). The subjects were considered "typical school girls from the Navajo reservation" representing the period 1930-40.

Anthropometric technique: With the subject standing on both feet, an outline of the right foot was traced on a sheet of paper by means of a split pencil held vertically. Tracings were made with "only the shoes removed" (p. 417). The projected landmarks were pternion, posteriorly, and, anteriorly, either the tip of the hallux (Steggerda, Crane and Steele, 1929) or the tip of the longest toe (Davenport and Steggerda, 1929).

Foot length (cm.) of Navajo Indian women of college age

AGE GROUP Mean	Range *(yrs.)*	N	MEAN	S. D.	V	MEAN STATURE
19.1	16 - 24	100	23.3	.93	4.0	155.7

Mean foot length for this sample of Navajo Indian women is identical with that obtained by Bowles on White females attending Vassar and Wellesley between 1880 and 1910. It is lower by 0.3 cm. to 0.8 cm. than the means reported on White college women for the period 1920 to 1940.

Integrating the results on young adult women from the fourteen investigations reviewed, major findings are:

1. The mean foot length of White females enrolled at North American colleges is greater today than half a century ago. For the period 1880-1910, measurements were accumulated on upwards of five thousand White women in attendance at five colleges. Pooled, these data yield a mean of 9.2 inches. During the years 1920-40, similar records were amassed at nine colleges on more than twelve

hundred White women students. The combined or general mean from these data is 9.4 inches. The difference in foot length is statistically significant at the 1 per cent level of confidence.

2. Individual records of foot length for physically normal White females between the ages of seventeen and twenty-five years fall along a continuum extending from 1.4 inches below the mean to 1.4 inches above the mean. With particular reference to either the interval 1880-1910, or the interval 1920-40, approximately 50 per cent of the measurements of foot length cluster between the limits of 0.3 inch on each side of the mean. Of the remainder, 30 per cent lie between 0.3 inch and 0.6 inch above and below the mean, while 20 per cent scatter beyond the limits of 0.6 inch. The standard deviation is barely half an inch.

3. Holding time of study constant, the mean foot length of young adult females is greater for Negroes than for Whites, and for Whites of northwest European ancestry than for Navajo Indians. The means available for comparison are from data collected in the decade 1930-40. Their values are 9.8 inches on Negroes, 9.4 inches on Whites, and 9.2 inches on Navajos. Each difference is statistically significant at the 1 per cent confidence level.

EARLY ADULTHOOD: MALES

Two analyses of data for foot length collected at Amherst College prior to 1890 were reported by Hitchcock and Seelye (1888) and by Hitchcock (1891). The earlier analysis was based on records for "all" students attending the college between 1882 and 1888; the later analysis, on "about five hundred" freshmen enrolling between 1884 and 1889. In both instances attention was confined to central tendency. The 1891 paper afforded central tendency values for each foot; the 1888 paper gave a single value obtained from composite records representing both feet.

Average foot length (cm.) of college men measured at Amherst, Massachusetts, prior to 1890

1882 - 88	1884 - 89	
Mid-foot	Right foot	Left foot
26.0	26.1	26.0

Related to previous findings, these averages indicate that the feet of White males are twice as long in early adulthood as at eighteen months after birth, and more than five times as long in early adulthood as at six months following fertilization.

The average length of each pes on male students in attendance at three eastern colleges prior to 1890 was investigated by Hitchcock, Jr. (1890). Data was secured from "nearly fifteen thousand recorded examinations" made at Yale University, Connecticut, Amherst College, Massachusetts, and Cornell University, New York. Apparently, the measurements were made by Seaver at Yale, Hitchcock Sr. at Amherst, and Hitchcock Jr. at Cornell. Identical averages (25.8 cm.) were obtained for the right and left pedes.

Extensive anthropometric tables derived from measurement of students attending Amherst College were published in 1892 and in 1900. The earlier tables (Hitchcock, 1892) were probably based on data collected over the preceding decade; the later tables, on data accumulated between 1882 and 1900. Both publications carried identical values for foot length; the tables differed only in the column headed "number of men measured".

In each series of tables the item "number of men measured" stood to represent over forty different dimensions of the body. Since a few of these dimensions (not including foot length) had been taken as early as 1861, and others added at various times to 1882, the numbers given no doubt exceed the records for foot length.

Measurements were made of "the extreme length of foot from the end of the first or second toe to the back of the heel, about one inch from the surface upon which the foot rests" (1900, p. 11). Both right and left foot were measured (see Table 13). The publication of

TABLE 13

Foot length (cm.) of males in attendance at Amherst College c. 1882-1900

AGE GROUP		NUMBER EXAMINED		MEAN	
Midpoint	Range (yrs.)	1892 report	1900 report	Right foot	Left foot
		Central tendency values by age			
17.5	17.0 - 17.9	90	326	26.1	26.1
18.5	18.0 - 18.9	220	735	26.1	26.1
20.0	19.0 - 20.9	540	1876	26.1	26.0
23.0	21.0 - 24.9	500	1709	26.2	26.1
Total examinations		7988	7988	26.0	25.9

Percentiles (disregarding age differences)

FOOT	N	5	10	30	50	70	90	95
Right	2230	24.2	24.6	25.4	26.0	26.6	27.5	27.9
Left	2230	24.1	24.5	25.4	26.0	26.6	27.5	27.9

1900 listed the largest records for foot length included among the data gathered to this time. These records — 30.3 cm. for the right foot and 30.0 cm. for the left — were obtained on a student measured in 1895.

Seaver (1909) reported averages for foot length on male students of four colleges (see Table 14), "the material having been obtained by one man in each institution" (p. 86). There was no further discussion of the material from Amherst, Cornell, or Wisconsin. The data representing Yale were seemingly collected by Seaver over the quarter-century beginning with 1883.

In orienting the foot for measurement, Seaver appears to have used two procedures. Either the subject was (a) in the sitting position, thighs parallel with the floor, legs perpendicular, and feet resting on the floor, or (b) in the erect position, the limb to be measured oriented with the thigh parallel with the floor, the leg perpendicular, and the foot resting on a stool. Foot length was determined on the nude foot

TABLE 14

Foot length "averages" (cm.) on four groups of college males studied prior to 1909

COLLEGE OR UNIVERSITY	AVERAGE AGE	RIGHT FOOT	LEFT FOOT
Yale	20.3	25.8	25.8
Wisconsin	20.1	26.0	26.0
Amherst	20.8	26.0	25.9
Cornell	....	25.8	25.8

with wooden sliding calipers — the fixed arm of the calipers contacting "the greater prominance of the os calcis", the shaft "touching the inner surface of both the heel and the ball of the foot", and the sliding arm contacting the tip of the longest toe (p. 37). It will be noted

that the averages for Amherst may have been reproduced from the tables compiled by Hitchcock in 1892 and/or 1900.

Measurements of pes length were obtained by Hall (1896) on male students attending Haverford College, Philadelphia, during the years 1889-93. The subjects were "exceptionally homogeneous as to (1) race, (2) nationality, (3) social and financial conditions, and (4) physical development" (p. 21). "Their parents were almost without exception born in America, and the families came originally from England. The families were with very few exceptions well-to-do" (p. 21). Unusual opportunities for physical development "induced a great majority of the students . . . to enter actively into athletics" (p. 21).

Length of the nude pes was measured with wooden sliding calipers "from the posterior surface of the calcaneum to the tip of the first or second toe" (p. 25). The examinations were made "under the most favorable circumstances" and the measurements taken with special care.

Foot length medians (cm.) on male students at Haverford College 1889-93

AGE GROUP			
Midpoint	Range (yrs.)	N	MEDIAN
18.5	17 - 20	685	25.9
c.22	20 and up	340	26.0

The combined median of 25.9 cm. closely approximates all of the previously cited figures for average foot length in college men.

Bowles (1932) presented analyses of foot length data for selected groups of men attending Harvard University in the period from about 1870 to 1917 (see Table 15). He utilized two major samples; one con-

TABLE 15

Foot length (cm.) of selected groups of men attending Harvard University 1870-1917

GROUP	AGE GROUP Mean	Range (yrs.)	N	MEAN	S. D.	V	RANGE
			Father-son findings				
Fathers	19.6	16 - 34	c.400	26.0	1.23	4.7	21.5 - 29.5
Sons	18.5	15 - 32	477	26.2	1.22	4.7	22.5 - 30.0
			Findings on brothers				
Older brothers			78	25.8	1.19	4.6	23.0 - 29.0
Younger brothers			78	25.9	1.08	4.2	24.0 - 28.0

sisting of approximately 400 Harvard men who later had sons enrolled at Harvard, the other composed of 477 sons of the aforementioned fathers. Both samples were considered largely "of Old American stock". The sons were stated to be "practically all of . . . two or three generation English, Scotch, Irish and German ancestry" (p. 5). Supplementary analyses were made for data on 78 pairs of brothers. Two subgroups were formed — one by taking the older member of each pair, and a second by taking the younger member. There was no discussion of the anthropometric landmarks and procedures employed in obtaining the measurements. The difference in foot length between fathers and sons is statistically significant at the 5 per cent level of confidence.

In the summer of 1939, Gould (1941) measured the foot length of "100 young men" of Old American stock[6] in attendance at the Southwestern Louisiana Institute, Lafayette. All of the men were "from small towns, villages, farms and trapping lands" in "the heart of the Acadian French country . . . of south central Louisiana" (pp. 292, 295). Their "near ancestry was completely or almost completely of French origin," with continuous residence "for several generations . . . in the subtropical climate of the gulf costal plain in Louisiana" (p. 310). The small proportion of non-French ancestry included "English, Irish, German, Dutch and Spanish" (p. 291). No less than "90 per cent of the grandparents were stated to have been born in Louisiana" (p. 292). With reference to socio-economic status, the subjects were described as "college students and school teachers . . . not often from families with a tradition of higher education" (pp. 295-6).

The anthropometric procedure followed was that "described by Doctor Hrdlička, from whom the writer received personal instruc-

Foot length (cm.) of 'Old American' college men attending Southwestern Louisiana Institute 1939

AGE GROUP Mean	Range (yrs.)	N	MEAN	S. D.	V
21.9	17 - 39	100	26.3	1.15	4.4

[6] Young men "whose ancestors along all lines, at least to the grandparental generation, had been born in the United States" (p. 298).

tion" (p. 299). It will be recalled that Hrdlička's method was first to have the subject raise his left foot and place it lightly on a stool and then to determine (along a line parallel with the long axis of this foot) the maximum distance from pternion to acropodion. Compared with the mean from Bowles for Harvard men (fathers) studied around half a century earlier, this mean is higher by 0.3 cm. The difference is statistically significant at the 5 per cent confidence level.

Burghardt (1937) analyzed foot length data on 51 Negro males and 61 White males in attendance at the University of Iowa during the academic year 1936-37. An attempt was made to enlist all the physically normal Negro students enrolled. "The basis for the selection of the White subjects was to match, as nearly as possible, the two groups according to height and weight" (p. 9). The White sample was drawn "in the main . . . from physical education classes" (p. 27). Within the 'Negro' sample the range of skin color was wide—"from an individual who could easily pass for White . . . to one of very dark color" (p. 10). The subjects "came, in general, from the middle western states" (p 42).

The records were obtained on the left foot either from direct measurement or from tracings. According to Burghardt: ". . . wooden calipers were used, the fixed arm just touched the back of the heel, the movable arm was adjusted according to the total length of the foot, and the calibrated part of the calipers touched the inner border of the foot" (p. 12). In a paper published two years later, Metheny made additional use of the Negro portion of the data stating that the procedure followed was "toes, sides and heel marked with pencil and measurement made from print, using millimeter ruler" (p. 44). This source gave credit for collection of the data to "Dr. Wayne W. Massey and Mr. Franklin Burghardt" (p. 42).

Foot length (cm.)of White and Negro males, University of Iowa, 1936-37

WHITE		NEGRO	
N	Mean	N	Mean
61	26.3	51	27.3

It should not be overlooked that the difference of 1.0 cm. in mean foot length accrues from two samples matched for stature and body weight.

Findings for pes length from "a random sample" of "100 American Negro men at Tuskegee Institute, Alabama" were reported by Steggerda and Petty (1942). The subjects were considered "a group of relatively homogenous Negro college males" belonging to "a more or less equal socio-economic class (pp. 275-6).

Pes length was determined on contour drawings of the right pes as the distance from the most forward projection of the great toe to the most posterior protrusion of the heel.

Foot length (cm.) of Negro college men at Tuskegee Institute, Alabama.

AGE GROUP					
Mean	Range *(yrs.)*	N	MEAN	S. D.	V
21.2	16 thru 23	100	27.4	1.40	5.1

The mean is similar to that obtained by Burghardt on Negro males. The measures of variability are appreciably higher than those reported on White college men by Bowles and Gould.

Colligation of the materials on foot length in early adulthood yields the following findings:

1. The mean foot length of men attending North American colleges is greater for Negroes than for Whites, and greater for Whites enrolled during recent years than for those enrolled half a century previously. Specifically, the means are 10.2 inches from data on White men at six institutions between about 1880 and 1910, 10.4 inches from data on White men at two institutions in the decade 1930-40, and 10.8 inches from data on Negro men at two institutions in the decade 1930-40. In each instance, these means exceed the corresponding means for females by one inch.

2. There is no clear difference in variability of foot length for young adult males and females. The median coefficient of variation from the studies on White college students of each sex is 4.6 per cent. For students of "Old American" stock, the coefficients obtained are 4.1 per cent (Gould) and 4.8 per cent (Carter) on females and 4.4 per cent (Gould) on males. The minimum coefficient reported is 4.0 per cent on Navajo Indian females (Steggerda); the maximum coefficient, 5.1 per cent on Negro males (Steggerda and Petty).

MIDDLE ADULTHOOD: WHITE AND NEGRO GROUPS

Utilizing a small series of adult males, Dunn (1923) studied the length of the foot "when subjected to body weight" and "when not subjected to body weight" (p. 623). From a sample of 108 males, about two-thirds soldiers and one-third college students, 70 were selected as "all having normal feet" (p. 581). Of these latter, 29 served as subjects.

Each foot was measured "with and without the entire body weight upon the arch . . . In order to apply the body weight in a uniform manner, the individual was asked to balance himself on one foot" (p. 571). Measurement was made "from the most posterior point on the heel to the tip of the great toe" (p. 572).

Foot length (cm.) of adult males taken under two procedures

	WEIGHTED FOOT				UNWEIGHTED FOOT			
AGE RANGE	Right		Left		Right		Left	
(yrs.)	N	Mean	N	Mean	N	Mean	N	Mean
16 - 34	29	26.5	29	26.1	29	26.0	29	26.0

It will be recalled that this tendency for the human foot to be longer "weighted" than "unweighted" is supported by the findings of Patek on undergraduate college women and of Meredith on elementary school children.

Davenport, Steggerda and Drager (1934) compared foot length data as obtained from tracings of the left foot, tracings of the right foot, and direct measurements of the right foot. A single adult subject was measured by Steggerda "at different times of the day through a number of days" (p. 266). Tracings of the left foot were found to be significantly longer than those of the right foot, and tracings of the right foot (split pencil method) significantly longer than measurements of foot length "taken directly by calipers" (p. 272). The mean differences were approximately 0.2 cm. and 0.3 cm., respectively. The direct measurements on the subject's right foot gave a mean of 25.4 cm.

Records for foot length were accumulated by Hrdlička (1925) on 456 "Old Americans". An "Old American" was defined as an American-

born, physically normal, non-senile adult of White ancestry "whose parents as well as all four grandparents" were born in the United States (pp. 4-5). Accordingly, the sample was made up of "third native generation" White Americans, exclusive of "the subadults . . . the senile . . . those obviously abnormal . . . those in poor health" (p. 7). The subjects were almost entirely of northwest European descent (i.e. their ancestors came mainly from the British Isles, Scandinavia, the Netherlands, France and Germany). They were predominantly residents of the District of Columbia and of northeastern states. Occupationally, they represented "the clerical, professional and at-ease" groups (p. 340) — the male series included "clerks, business men, professional men, members of Congress and men of leisure, artisans and farmers"; the female series, "clerks, women in business or professions, housewives, and women of leisure" (p. 7).

Measurements were taken "on the left foot", using aluminum, broad-branched, sliding calipers (the Hrdlička compass). During measurement, the subject's left foot rested lightly on "the bench used for measuring the height sitting," while his body weight was supported primarily through the right foot. With the shaft of the instrument paralleling the long axis of the left foot, one branch was placed in contact with pternion and the other branch "brought lightly to the most distal part of the longest toe." The data were collected largely between 1912 and 1917.

Foot length (cm.) of 'Old American' adults measured c. 1912-17

SEX	MEAN AGE (yrs.)	N	MINIMUM VALUE	PERCENTILES: 10	25	50	75	90	MAXIMUM VALUE
Males	42.5	246	22.6	24.7	25.4	26.1	26.8	27.6	29.6
Females	41.0	210	20.8	22.1	22.7	23.3	24.0	24.7	26.6

Hrdlička secured supplementary data on twelve groups of adult male immigrants "within the same age limits as the Old Americans" (twenty-four to sixty years) and "measured by the same method" (pp. 155, 340). It will be seen that the average foot length of adult males was found to be highest on immigrants from Poland, intermediate on "Old Americans", and lowest on South Italian immigrants (Table 16).

TABLE 16

Foot length (cm.) on adult males of twelve ethnic groups

GROUP	MEAN AGE (yrs.)	N	MEAN	GROUP	MEAN AGE (yrs.)	N	MEAN
Poles	30.2	50	26.6	English	29.3	20	26.2
Croatians	35.3	50	26.5	Greeks	33.9	50	26.1
Irish	30.2	35	26.4	Rumanians	36.5	50	26.0
North Italians	33.9	50	26.4	Armenians	29.7	25	25.8
Russians	32.0	50	26.2	Russian Jews	31.5	50	25.8
Hungarians	35.6	50	26.2	South Italians	30.4	50	25.7

During the years 1918-19, records of male foot length — 439 for each pes — were obtained by Bean (1919). The subjects were "98 students attending the University of Virginia, and 341 soldiers, drafted men who had recently entered the truck school near the university . . . The students were between 18 and 26 years of age and the soldiers were between 21 and 40 inclusive" (p. 280). "The soldiers were largely from the laboring classes and the students from the leisure classes, and both, almost without exception, represented the Old American stock who have been in this country for at least three generations, almost entirely in Virginia" (p. 281).

Foot length (cm.) of 'Old American' males measured 1918-19 in Virginia

RANGE OF AGE GROUP (yrs.)	LEFT FOOT N	LEFT FOOT Mean	RIGHT FOOT N	RIGHT FOOT Mean
18 - 40	439	26.0	439	26.1

Bean does not discuss the anthropometric technique employed. His findings are practically identical with those of Hrdlička on "Old American" adult males.

Steggerda (1932b) gathered measurements of pes length on 130 adults of Dutch ancestry, members of his family. Some of the subjects were born and raised in the Netherlands, some in North America.

"The ancestors of all . . . came from the northern provinces of the Netherlands" (p. 310). There was no trace of mixture with other ethnic groups "for several generations at least" (p. 310). Fifty-seven of the subjects resided in the Netherlands and were measured during the summer of 1930; the remaining 63 resided in Ottawa County, Michigan, and were measured over a period of "several years". The American Dutch included "persons of both the maternal and paternal lines of the author," while the European Dutch included "only the author's paternal line" (p. 335).

"All measurements were taken by the author with a uniform technique" (p. 311). After each subject had "removed shoes", a tracing was made of the right pes, and length determined from this tracing as "the maximum distance from the great toe to the heel" (p. 323).

Foot length (cm.) for "interrelated" adults of Dutch ancestry

SEX	MEAN AGE	N	MEAN	S. D.	V
Males	35	c.70	26.6	1.23	4.6
Females	36	c.60	24.2	1.11	4.6

These means are higher than those from Hrdlička's samples of "Old Americans" by 0.9 cm. for females and 0.5 cm. for males.

Gould (1941) collected and analyzed foot length records on 100 adult males of French ancestry "whose forebears had lived for about 300 years" in the maritime area of eastern Canada called by the early colonists "La Cadie, Arcadie, or Acadie" (pp. 289, 310). During the centuries since the first permanent settlement in 1605, "the territory known as Acadia has had indefinite and shifting boundaries . . . in Nova Scotia . . . New Brunswick . . . the Gaspé peninsula . . . Prince Edward Island and Cape Breton Island" (p. 290). In many communities "there has been little infiltration from the outside and the Acadians have married among themselves" (p. 295).

The subjects, considered to typify "descendants of the original stock," were drawn from various parts of New Brunswick province and Prince Edward Island. They represented "families of moderate or small means, living in small towns, villages or in the country" (p. 295). Tabulation of occupational data gave the following: "54 manual

workers including 22 farmers, 14 laborers, 9 fishermen, 3 garage mechanics and 6 various; and 46 others" including varied commercial and professional occupations (p. 296).

The data were amassed during the summer of 1940. Length of the left foot was taken from pternion to acropodion. With reference to orientation and pressure, the procedure was "as described by Doctor Hrdlička, from whom the writer received personal instruction" (p. 299).

Foot length (cm.) on "Acadian French males of Canada" studied 1940

AGE GROUP					
Mean *(yrs.)*	Range	N	MEAN	S. D.	V
27.2	17 - 46	100	26.2	1.03	3.9

These findings are similar to those obtained by Gould on "Old American" college men, largely of French ancestry, studied in 1939 at the Southwestern Louisiana Institute.

Davenport and Steggerda (1929) analyzed foot length data on 317 adult residents of Jamaica, British West Indies—97 Negroes, 92 Whites, and 128 Negro-White hybrids. As far as it was possible to ascertain, the Negro subjects had the "genetic constitution" of "pure African Negro" and the White subjects the "genetic constitution" of "European". The hybrid subjects were characterized as "sambo, mulatto, quadroon, or more complex cross" (p. 20). All three groups were selected to represent approximately the same socio-economic level; they were drawn primarily from the agricultural class, though in addition to "cultivators" there were appreciable numbers of college students, firemen, candidates for the police force, seamen, and penitentiary inmates. The data were collected in 1926-27.

With the subject "standing on both feet, his right foot on a sheet of paper, the outline of the foot was traced" (p. 27). On this tracing, "taken with a split pencil held in a vertical position while passing around the contour," measurement was made of "the horizontal distance from heel to tip of the longest toe" (p. 134).

Foot length (cm.) of three groups of Jamaican adults measured 1926-27

GROUP	MALES (Ages c.18 - 40 yrs.)				FEMALES (Ages c.18 - 35 yrs.)			
	N	Mean	S. D.	V	N	Mean	S. D.	V
White	48	25.7	1.65	6.4	44	23.6	1.21	5.1
Negro	53	26.6	1.46	5.5	44	24.5	1.32	5.4
Hybrid	89	26.0	1.27	4.9	39	24.5	1.40	5.7

As at the college ages, mean foot length is greater for males than for females, and greater for Negroes than for Whites.

Individual records were given for 19 of the 92 White subjects, all members of one family. The family was of "German origin" and had a pedigree which included seven first- and second-cousin intermarriages.

G. G., his wife, and two sons

Relationship	G. G.	Wife of G. G.	Sons of G. G. (brothers)	
Sex and age *(yrs.)*	Male: 57	Female: 57	Male: 34	Male: 20
Foot length	26.1	23.9	25.9	26.3

W. S. and his two nephews

Relationship	W.S.	Nephews of W. S. (brothers)	
Sex and age *(yrs.)*	Male: 58	Male: 20.5	Male: 19
Foot length	24.3	24.4	23.5

Two brothers and two of their first cousins

Relationship	Brothers		First cousins (siblings)	
Sex and age *(yrs.)*	Male: 30	Male: 24	Male: 27	Female: 23
Foot length	23.3	25.6	25.6	24.4

Three pairs of siblings, first cousins

Relationship	Siblings		First cousins (siblings)		First cousins (siblings)	
Sex and age *(yrs.)*	Male: 28	Female: 17	Male: 23	Female: 18	Male: 26	Female: 23
Foot length	24.0	23.2	23.7	20.5	23.0	21.4

First cousins

Sex and age *(yrs.)*	Male: 21	Male: 20
Foot length	25.0	24.3

On the 14 males, the values for foot length are distributed between 23.0 cm. and 26.1 cm. For the three pairs of brothers, the fraternal differences in foot length are 0.4 cm., 0.9 cm., and 2.3 cm.

Measurements of foot length were accumulated by Hrdlička (1928) on a small series of American Negro adults, "All of whom could with full confidence be regarded as full-blood" (p. 27). After eliminating "the young, old, crippled, or diseased" (p. 15) there remained a sample of twenty males and six females. "All were in good physical condition, and no one showed any feature suggesting either a White or Indian mixture" (p. 16). They resided in Washington, D. C., and were "mainly laborers and servants" (p. 27). Collection of the data was intermittent, covering an extended (unspecified) period beginning in 1903.

Foot length was taken as the "maximum length" of the left pes, parallel to its long axis. The pes rested on a bench, with the subject carrying his body weight primarily through the right limb. Special study was made "as to the relative length of the first two toes" (p. 25). For both males and females together, in about 20 per cent "the first and second toes were of equal length" and in approximately 12 per cent "the second toe was distinctly the longer" (p. 26).

Foot length (cm.) of full-blood American Negro "laborers and servants"

AGE GROUP							PERCENTILES		
Mean	Range (yrs.)	SEX	N	MEAN	S. D.	V	25th	75th	RANGE
36.2	25 - 60	Males	20	26.8	1.26	4.7	26.0	27.5	23.6 - 29.3
21.7	19 - 25	Females	6	25.4	....	....	....	....	22.6 - 26.9

The mean for males is 0.6 cm. lower than that obtained on Negro college men in 1942 by Steggerda and Petty. On the assumption of random selection, there is less than one chance in fifteen that the two samples represent one population. Further alignment of the two studies shows them to differ in anthropometric procedure, in socio-economic level, and in the time the data were collected. To the writer, it appears more probable that the difference in foot length is related to socio-economic selection and/or secular variation than that it accrues from systematic methodological differences or represents no more than a chance difference from random sampling.

Employing White and Negro adult cadavera of each sex, Todd and Lindala (1928) reported statistical reductions from four distributions for foot length. The cadavera were selected to yield "unimpeachable records to form standard samples for comparison" (p. 94). Rejection was made of any cadaver "crippled, deformed or mutilated . . . obviously oedematous . . . autopsied . . . embalmed by the undertaker . . . in an advanced state of decomposition" (p. 39). The subjects — 136 White adults and 132 Negro adults — were drawn from among 1000 cadavera of former residents of Cleveland, Ohio, "deposited in the anatomical laboratory of Western Reserve University" (p. 36). Their age distribution was not discussed.

The majority of the specimens represented "the lower strata of society" (the "indigent poor"), though "many bodies were those of persons of middle class birth" (p. 37). "The White material was largely alien, from Northern Europe, or native American of the second generation whose parents hailed from Northern Europe. The Negro material was mainly of recent migration from the South, particularly from Alabama" (p. 95). The Negro material was considered "thoroughly representative of the American Negro, largely uninfluenced by the White" (p. 38) — in pigmentation the skin was found to be fully as dark and homogeneous as for other so-called "American Negro" or "pure-blood" series.

TABLE 17

Foot length (cm.) on White and Negro adult cadavera

RACE	SEX	NUMBER	MEAN	S. D.	V
Negro	Male	100	25.6	1.39	5.4
White	Male	100	24.4	1.19	4.9
Negro	Female	32	23.1	1.18	5.1
White	Female	36	21.5	1.36	6.3

The left foot was measured from pternion to acropodion (see Table 17). All measurements were made by one individual (Todd). Compared with the means obtained in other investigations on similar race-sex subgroups, these means are appreciably smaller throughout. Explicitly, the lowest North American means reported on living subjects are 26.8 cm. for Negro males ("laborers and servants" studied

by Hrdlička, 1928), 25.7 cm. for White males (South Italian immigrants studied by Hrdlička, 1925), 25.0 cm. for Negro females (college women studied by Steggerda and Petty, 1940), and 22.9 cm. for White females (college women studied by Hitchcock, 1891). In every instance the means of Todd and Lindala on cadavera are lower by upwards of a centimeter.

In many respects, the findings for foot length in middle adulthood are no different than those for early adulthood. It follows, then, that certain statements can be made covering all ages beginning at the close of the second decade and extending to the end of the fourth decade. Generalizations for this age span from the entire series of results available on samples of White and Negro adults are:

1. The mean foot length of North American White males is 10.3 inches and that of White females 9.3 inches. Corresponding means for North American Negro males and females are higher by approximately four-tenths of an inch.

2. There is a slight tendency for the standard deviation to be higher for males than for females. This tendency is neither marked nor fully consistent from study to study. It is a close approximation to regard the standard deviation as one-half inch for males and slightly less for females.

3. For each sex, adult foot length is so distributed that 50 per cent of the measures lie between the limits of 0.3 inch above and below the mean, 30 per cent between these points and 0.6 inch above and below the mean, and the remaining 20 per cent half between 0.6 inch and 1.4 inches below the mean and the other half between 0.6 inch and 1.4 inches above the mean. These figures are substantially supported by the investigations on White adults, while the smaller amount of information on Negro adults appears equally well represented by the same zones (taken, of course, above and below the Negro means).

MIDDLE ADULTHOOD: AMERICAN INDIAN GROUPS

Between the years 1898 and 1910, during six expeditions to northern Mexico and the southwestern part of the United States, Hrdlička (1935) amassed nearly twelve hundred measurements of adult foot length on "healthy, fullblood" Pueblo and non-Pueblo Indians. "The endeavor to include fullbloods only (those "free from any recognizable trace of mixture with either the White or the Negro," p. 245) was held paramount throughout the work . . . With the care taken, any

disturbance of the data from the possible inclusion of mixtures must be immaterial" (p. 241). Among the fifteen tribes visited and found willing to have measurements taken on either the adult males or the adults of both sexes, "no selection of individuals was practiced except as to the mixbloods and the senile, who were strictly avoided" (p. 266). The subjects were 271 "adult fullblood Pueblos" residing mainly in New Mexico and Arizona, and 921 "fullblood adult Indians" representing "all the more important" non-Pueblo tribes "of the territories extending from southern Utah and Colorado to the State of Morelos in Mexico" (p. 242).

The data "were gathered with all possible care as to accuracy" (p 265). Measurement was made of the maximum straight line distance along the foot axis. "The foot measured was the left, and that in its

TABLE 18

Foot length (cm.) on healthy adult fullblood Indians of the southwest United States and northern Mexico

Central tendency values by tribe

TRIBE	MALES		FEMALES		TRIBE	MALES		FEMALES	
	N	Mean	N	Mean		N	Mean	N	Mean
Pueblos	183	24.3	88	22.2	Apache (Wh. R)	52	25.6	31	22.9
Tarahumare	22	24.4	10	22.0	Pima	53	25.8	30	23.5
Otomi	50	24.5	25	21.8	Pagago	50	25.8	30	23.1
Aztec	54	24.6	30	22.3	Zuma	29	26.0	5	24.0
Tarasco	50	24.8	30	22.4	Mohave	45	26.0	26	23.2
Navaho	49	25.1	30	23.1	Maricopa	40	26.6	30	24.4
Cora	51	25.1	10	23.0	Yaqui	19	27.0		
So. Ute	50	25.2	20	23.3	Total data	797	25.1	395	22.8

Central tendency values for three age groups

TRIBE	Below 28 yrs.		28 to 50 yrs.		Above 50 yrs.	
	N	MEAN	N	MEAN	N	MEAN
			Males			
Pueblos	37	24.3	116	24.4	30	24.4
Others	135	25.3	302	25.5	78	25.0
			Females			
Pueblos	17	22.3	58	22.2	12	22.4
Others	46	22.8	183	23.5	28	23.2

Central tendency and variability values for Pueblo Indians

SEX	N	MEAN	PERCENTILES		RANGE
			25th	75th	
Males	183	24.3	23.6	25.0	21.4 - 27.1
Females	88	22.2	21.5	22.8	20.4 - 24.9

Central tendency values for Pueblo subgroups

SUBGROUPS	MALES		FEMALES	
	N	Mean	N	Mean
Tanoan (Hano)	19	23.8	10	22.1
Zuni	60	24.2	30	22.1
Hope	39	24.3	19	21.8
Queres (Laguna)	60	24.7	29	22.7

natural condition, without subjection to the weight of the body" (p. 435).

The means for different tribes (see Table 18) vary considerably. Maricopa Indians yield means higher than those on Pueblos by 2.3 cm. for males and 2.2 cm. for females. It is of interest that "up to the time of these examinations the Pueblos went either barefoot, or wore sandals which in no way constricted the foot" (p. 437).

In 1924, foot length data were collected by Schultz (1926) on 37 "Central-American Indians" of two tribes. The subjects were "pure-blooded" Indians living in the eastern part of Nicaragua. They "belonged to the Rama and Sumu tribes and numbered 25 and 12 adult men respectively" (p. 65).

Measurement was made of the left foot. The pternion-acropodion distance was obtained "with the foot on a bench, so that the body weight did not rest on the foot" (p. 66).

Foot length (cm.) on two groups of Nicaraguan male Indians measured 1924

AGE GROUP		TRIBE	N	MEAN	PERCENTILES		RANGE
Mean	Range (yrs.)				25th	75th	
29	21 - 40	Rama	25	25.2	24.5	25.9	22.0 - 27.9
c.30	20 - 50	Sumu	12	24.2	....	....	20.5 - 27.1

On the average, the foot length of the Ramas was found to exceed that of the Sumus. The mean stature of the Ramas was 166.1 cm., that of the Sumus 158.2 cm.

Hrdlička (1926) reported an analyzis of pes length data obtained

by an assistant on 66 Indian adults of Panama (Table 19). "In the early months of 1924 Mr. John L. Baer . . . secured a series of measurements on two tribes of Indian inhabitants . . . from the Gulf of Darien, Panama" (p. 1). "The two tribes, in a loose way neighbors, were the Cunas and the Chocos" (p. 2). The former resided "along the coast," the latter "inland".

Since Mr. Baer was trained by Hrdlička, it can be assumed that in each instance the left pes was oriented for measurement upon a low bench and its maximum length determined with broad-branched, sliding calipers.

TABLE 19

Foot length (cm.) on adult Indians of Darien, Panama

AGE GROUP						
Mean *(yrs.)*	Range *(yrs.)*	TRIBE	SEX	N	MEAN	RANGE
30	20 - 58	Choco	Males	27	23.6	22.2 - 25.4
30	19 - 40	Choco	Females	10	21.9	20.8 - 24.1
32	21 - 60	Cuna	Males	20	24.1	22.2 - 25.7
31	18 - 45	Cuna	Females	9	22.1	20.4 - 23.1

In the same paper, Hrdlička presented data on eight Indians "from the San Blas Territory, Panama" (p. 8). They ranged in age from ten to forty years. Five were of normal pigmentation and three albinos. All were brought to Washington, D. C., by Mr. R. O. Marsh. The measurements were made by Hrdlička in the latter part of 1924 (Table 20).

TABLE 20

Foot length records on Indians of San Blas, Panama

SUBJECT	SEX	APPROXIMATE AGE *(yrs.)*	FOOT LENGTH *(cm.)*
		Normally pigmented	
1	Male	35	24.9
2	Male	28	22.5
3	Male	28	22.7
4	Male	40	24.5
5	Female	35	23.3
		Albino	
6	Male	17	23.2
7	Male	10	21.8
8	Female*	15	23.5

*Subject 8 was the daughter of Subjects 4 and 5.

In 1925, measurements of foot length were made by Harris (1926) on 46 adult "Indians of the San Blas Coast" (p. 57). These subjects were drawn from the two localities of Alligandi and Portogandi. They were considered to represent longstanding "purity of blood" and "relatively close inbreeding" (p. 57). Six of the 46 were partial albinos or so-called "White Indians."

"Reproductions in two dimensions were made of the foot," and data for foot length secured "from these outline tracings" (p. 41) (see Table 21).

TABLE 21

Foot length (cm.) of San Blas (Tuli) Indians measured in 1925

SERIES	AGE GROUP Mean	AGE GROUP Range (yrs.)	SEX	N	MEAN	RANGE
Normal pigmentation	32.0	17 - 55	Males	14	23.0	22.1 - 24.6
Partial albino	28.4	22 - 40	Males	5	22.1	21.1 - 23.2
Normal pigmentation	30.5	18 - 60	Females	26	21.0	19.3 - 22.3
Partial albino		35 - 40	Female	1	21.7	....

By pooling the "normal pigmentation" and "partial albino" series from this study, and the six records at ages seventeen to forty years on San Blas Indians from Hrdlička (1926), the following tabulation was obtained:

Foot length (cm.) on adult Indians of San Blas Panama
(Derived from data collected by Hrdlička in 1924 and Harris in 1925)

AGE GROUP Mean	AGE GROUP Range (yrs.)	SEX	N	MEAN	PERCENTILES 25th	PERCENTILES 75th	RANGE
30.8	17 - 55	Males	24	23.0	22.3	23.6	21.1 - 24.9
30.9	18 - 60	Females	28	21.1	20.5	21.7	19.3 - 23.3

These means are lower than any others reported on adult inhabitants of North or Central America.

Collins (1925) took measurements of foot length on 50 adult "Choctaw in the vicinity of Philadelphia, Mississippi" (p. 425). The subjects were obtained through the cooperation of the Indian Agency of Philadelphia. While an attempt was made to reject individuals of "mixed blood," there remained among those studied some "with traces of White" (pp. 426, 432). The data were collected in 1925.

"The anthropometrical method employed was that outlined by Dr. Hrdlička" (p. 426). In other words, the left extremity was oriented for measurement with the foot on a bench, the leg perpendicular, and the thigh approximately at right angles with the leg and with the torso. Measurement was made from pternion to acropodion.

Foot length (cm.) of southeastern (Choctaw) Indians measured 1925

AGE GROUP		SEX	N	MEAN	PERCENTILES		RANGE
Mean	Range (yrs.)				25th	75th	
32	17 - 67	Males	33	26.3	25.5	27.2	24.2 - 29.8
33	20 - 58	Females	17	23.8	....	....	22.0 - 27.8

The following year, Collins (1928) obtained foot length measurements on "additional adult Choctaw" living "in small farming communities . . . in east-central Mississippi" (p. 353). As in the previous paper, it was emphasized that the data were "not to be regarded as those of full-blooded Choctaw" (p. 355). Elaborating, Collins stated: "The extent of miscegenation taking place at the present time is negligible, and this is a condition which seems to have prevailed for a number of years past. The degree of purity of the Mississippi Choctaw, therefore, depends on the amount of White and Negro blood absorbed during the earlier stages of their contact with these peoples, the greater part of such admixture having probably been brought about during the century or a little more following about 1750 A. D." (p. 353). In analysis, the 1925 and 1926 data were pooled.

Foot length (cm.) of adult Choctaw Indians studied 1925-26

SEX	N	MEAN	RANGE
Males	84	26.2	24.2 - 29.8
Females	46	23.6	22.0 - 27.8

Compared with other Indian groups, these means are similar to those obtained by Hrdlička on the Mohave and Pima. Compared with White groups, the male mean is identical with the means obtained by Gould on "Acadian French males of Canada", Hrdlička on Russian and Hungarian immigrants, and Bowles on students at Harvard.

Hrdlička (1931) studied foot length on a small series of men of the "Yankton and Oglala" subdivisions of the Sioux ("more properly, Dakhota") Indians. The subjects were "twenty normal individuals," all adults, and "unquestionably full-bloods" (pp. 158, 128). They were examined at "the Fort Yates, Cheyenne River, and Pine Ridge reservations, in North and South Dakota" (p. 128).

The "maximum length" of the "left foot" was measured, "with the foot reposing lightly on a flat surface and the weight of the body thrown on the right foot" (p. 160). The determinations were made by the author, using his standardized broad-branched calipers and exercising "all due care" (p. 128).

Foot length (cm.) on males of two subdivisions of the Dakhota or Sioux

AGE	N	MEAN
Over 21 yrs.	20	26.8

The mean is identical with the mean reported by Hrdlička on full-blood Negro "laborers and servants", similar to Hrdlička's means for Maricopa and Yaqui Indians, 2.5 cm. higher than the Hrdlička mean for Pueblo Indians, and 3.8 cm. higher than the Harris mean for Tuli (San Blas) Indians.

Measurements of pes length were obtained by Steggerda (1932a) on 101 adult Maya Indians living in the north central part of the Yucatan peninsula. The subjects were "relatively pure Maya . . . from towns in the vicinity of Chichen Itzá" (p. 2). It was estimated that none had more than "one-eighth to three-sixteenths White blood" (p. 4). In a later publication (1941) Steggerda stated that the Mayas eat a predominantly carbohydrate diet, live under relatively poor conditions of housing and medical care, but have high standards of personal cleanliness. They are agricultural people whose vocational activities center around the cultivation (men) and preparation (women) of food. Average stature approximates 155 cm. for males and 143 cm. for females.

For each subject an outline of the right pes was traced on a sheet of paper, and this tracing used to obtain "the maximum distance from the great toe to the heel" (pp. 10, 52).

Foot length (cm.) on adult Maya Indians of Yucatan studied 1931

AGE GROUP						
Mean	Range (yrs.)	SEX	N	MEAN	S. D.	V.
30.6	15 - 60	Males	50	24.7	.93	3.8
28.8	15 - 60	Females	51	22.5	1.05	4.7

Means similar in magnitude were obtained by Hrdlička on samples from the Aztec and Tarasco tribes.

Goldstein (1934) analyzed foot length measurements taken in 1931 on 52 physically normal, non-decrepit adult Comanches, residing "on and near a government reservation in south-central Oklahoma" (p. 289). The sample comprised 14 full-blood males, 24 full-blood females, and 14 males considered probably full-blood. By "full-blood" was meant "a person with no other blood than that of his tribe as far back as he can remember, and as far as other, older, members of the tribe recall; this criterion must agree with the physical diagnosis based on character of hair, color of eyes and hair, Hrdlička's skin reaction, pigmentation, general appearance, etc." (p. 291). Subjects were designated "probably full-blood" in instances where they "appeared full-blood, yet for one reason or another, the diagnosis could not be as certain as desirable" (p. 291). It was stated that the Comanches were "for the most part leading a sedentary, half-hearted agricultural existence. They were in immediate pre-reservation times a true and the southermost plains tribe, noted as daring and ruthless raiders, who followed and lived largely on the buffalo" (p. 289).

Description of anthropometric technique was restricted to two statements; one indicating that the "methods followed" were "those indorsed by the International Agreement," the other acknowledging Hrdlička for "instructions in method" (p. 292). With specific reference to foot length, the latter statement appears the more applicable. Measurements were taken on the left foot, not on the right foot as

TABLE 22

Foot length (cm.) of adult Comanche Indians measured 1931

SERIES	AGE GROUP (APPROX.) Mean (yrs.)	Range	N	MEAN	RANGE
Full-blood:					
Males	56.8	26 - 76	14	26.0	23.2 - 27.8
Females	52.0	28 - 70	24	24.1	22.5 - 25.9
Probably full-blood:					
Males	48.4	25 - 61	14	26.2	25.0 - 28.5

recommended in the Geneva Agreement. Probably they were made directly on the foot in the manner adopted by Hrdlička, not on a "contour of the foot" traced as stipulated in the Geneva Agreement. "Several instances were noted where the second toe of the foot was distinctly longer than the first or big toe" (p. 299).

The female mean (see Table 22) is larger than the means from all other groups of female Indians except the Maricopa (Hrdlička, 1935). The male means practically coincide with the mean on Chotaw males, (Collins, 1928) and are exceeded only by the Hrdlička (1931, '35) means for males of the Maricopa, Dakhota and Yaqui tribes.

Ten investigations on Indian adults residing in North and Central America have been reviewed. The materials which they afford may now be synthesized and compared with findings for White and Negro adults.

1. Foot length data have been accumulated on Indians of twenty-four different groups or tribes. With almost all these groups the anthropometric technique was that advocated by Hrdlička (*i. e.* after the subject had raised his left foot and placed it on a stool or bench, measurement was made of its maximum length from pternion to acropodion).

2. Different groups of American Indians have been found to differ markedly in foot length. For males, means less than 9.5 inches have been reported on the Tuli and Choco Indians of Central America, and means above 10.5 inches on North American Indians of the Yaqui tribe and of the "Yankton and Oglala" subdivisions of the Dakhota (Sioux). For females, the lowest mean is 8.3 inches on a sample of Tuli, the highest 9.6 inches on a sample of Maricopa. These differences between

tribes are fully as great as the sex differences within tribes. The Maricopa mean for females exceeds the Tuli and Choco means for males, while the means are identical on Cuna males and Comanche females.

3. By combining all of the data for foot length on Indian adults (including those from Steggerda on Navaho females of college age), it is possible to compute general or composite means based upon 1,087 male records and 663 female records. When these computations are made, and the results placed in juxtaposition with the general means on White and Negro adults, the following progressions accrue: For males, 9.9 inches on Indians, 10.3 inches on Whites and 10.7 inches on Negroes; for females, 9.0 inches on Indians, 9.3 inches on Whites and 9.7 inches on Negroes.

4. Figures relating to variability in foot length are available on nine groups of Indian males and eight groups of Indian females. For four groups of each, only the minimum and maximum values are presented. On an additional four groups of males and two of females these extreme values are supplemented with the 25th and 75th percentiles. For the remaining two samples of females and one of males standard deviations are afforded. The standard deviations (Maya and Navaho samples) approximate 0.4 inch, the interquartile distances 0.6 inch. Differences between the minimum and maximum values vary from 1.1 inches on a series of nine Cuna females to 2.6 inches on twelve Sumu males.

SUMMARY

This paper is intended to contribute to three facets of scientific knowledge of particular interest to human biologists. In question form, these facets may be characterized as follows:

1. What is the typical course of growth in human foot length during ontogeny? How widely separated are the limits of normal dispersion at successive ages?

2. At what ages, and by how much, does the foot length of males exceed that of females? To what extent are there differences in foot length associated with racial, secular, cultural, or other variables?

3. Does the pattern of growth in foot length differ appreciably from individual to individual? Are there greater individual variations in rate of growth during some age periods than during others?

An attempt is made to assemble all of the information on human foot length for inhabitants of North and Central America currently

accessible. Materials from upwards of sixty investigations are brought together and subjected to review, collation, and synthesis. Included among these materials are data from seven previously unpublished studies.

Careful consideration is given to experimental procedure. In presenting each study, no greater attention is placed upon depicting the results than upon describing the sample, indicating the criteria used in selection and rejection of subjects, noting the manner in which the lower extremities were oriented, specifying whether the right or left foot was measured, designating the landmarks employed, stipulating the composition of subgroups, and showing the scope of analysis and the statistical media employed to represent the data.

Selected findings are:

1. The human foot becomes macroscopically identifiable between five and six weeks following fertilization. By eight weeks there are individual toes, the contour of the heel is indicated, and the distance from acropodion to pternion approximates 0.2 inch. Approximate means at later prenatal ages are 0.6 inch at three months, 2.0 inches at six months and, at nine months or "term", 3.2 inches for males and 3.1 inches for females.

2. Over the first two decades of postnatal life the foot length of the typical White male (total available data on inhabitants of North America) increases from 3.2 inches to 10.3 inches. Typical values for intermediate ages are 4.0 inches at six months, 5.1 inches at eighteen months, 6.0 inches at three years, 7.1 inches at six years, 8.5 inches at ten years and 10.0 inches at sixteen years. The female values are lower by about one-tenth of an inch throughout the first decade, and by one inch at the close of the second decade.

3. In general, the mean curve for foot length registers a slowing rate of growth from early fetal life to early adulthood. The decrease in growth rate is most rapid in the young fetus and tends to slacken more and more gradually with advancing age. This may be illustrated by a listing of the increasing amounts of time taken for the foot to double its length. Foot length doubles during the fourth prenatal month (one month), during the period from three months before birth to six months after birth (nine months), during the first four postnatal years (four years), between the middle of the first postnatal year and nine years (over eight years) and, for males, between the

middle of the second postnatal year and eighteen years (over sixteen years).

4. While the average female has shorter feet than the average male, at all ages from infancy to adolescence the female is nearer adult status than is the male. This follows since the sex difference in mean foot length is considerably greater in adulthood than during earlier ontogenetic periods. At birth, White females have attained approximately 34 per cent of their foot length at maturity, White males 31 per cent. At ten years of age the percentages reached are 90 for females and 82 for males.

5. At no early fetal age have individual differences in foot length been shown to exceed one-half inch, and at no age during the first postnatal year do they exceed one inch. Specific for sex and for White subjects, the normal range approximates two inches by the close of the first decade and three inches in adulthood. At all ages, variability tends to be slightly higher for males than for females.

6. Means derived from large series of data show the foot to be longer on White students attending North American colleges in recent years than on those in attendance half a century ago. The means for females are 9.2 inches covering the period 1880-1910 and 9.4 inches over the period 1920-40. Parallel averages for males are 10.2 inches and 10.4 inches.

7. On the whole, mean foot length in adulthood is highest for Negroes, intermediate for Whites and lowest for American Indians. Explicitly, the composite values from data on living, non-senile subjects are 10.7 inches, 10.3 inches and 9.9 inches for males, and 9.7 inches, 9.3 inches and 9.0 inches for females. The means of different component groups vary between 10.8 inches and 10.5 inches for Negro males, 10.5 inches and 10.1 inches for White males, 10.6 inches and 9.1 inches for Indian males, 10.0 inches and 9.6 inches for Negro females, 9.5 inches and 9.0 inches for White females, and 9.6 inches and 8.3 inches for Indian females. The dispersion of the Indian means contrasts sharply with the comparative homogeneity of the means on Whites and on Negroes. This contrast is apparently related to the "relatively close inbreeding" of certain Indian tribes and the greater heterogeneity of all the White and Negro samples.

8. The largest record for adult foot length is 12.4 inches on a Negro male, the smallest 7.6 inches on a Tuli female. The maximum female record is 10.9 inches on a Choctaw Indian, the minimum male

record 8.1 inches on a Sumu Indian. Other extreme values are maxima of 11.9 inches for White males and 11.7 inches for Indian males (Choctaw) and minima of 8.5 inches for White males and 9.3 inches for Negro males.

BIBLIOGRAPHY

AREY, LESLIE B. 1934. Developmental Anatomy: A textbook and laboratory manual or embryology. *Philadelphia:* W. B. Saunders, 593 pp.

BAKWIN, HARRY, and BAKWIN, RUTH M. 1934. Body build in infants: V. Anthropometry in the new born. HUM. BIOL., 6, 612-626. (See also, BAKWIN, HARRY, and BAKWIN, RUTH M. 1934. External dimensions of the new-born. *Amer. J. Dis. Child.*, 48, 1234-1236; BAKWIN, HARRY, and BAKWIN, RUTH M. 1931. Body build in infants: I. The technique of measuring the external dimensions of the body in infants. *J. Clin. Invest.*, 10, 369-375.)

————, and ————. 1936. Growth of thirty-two external dimensions during the first year of life. *J. Pediat.*, 8, 177-183.

BARDEEN, CHARLES R. 1905. Studies of the development of the human skeleton. *Amer. J. Anat.*, 4, 265-302.

————, and LEWIS, WARREN H. 1901. Development of the limbs, body-wall and back in man. *Amer. J. Anat.*, 1, 1-35 + 9 plates.

BEALL, ELIZABETH. 1939. The relation of various anthropometric measurements of selected college women to success in certain physical activities. *Teachers College, Cont. to Educ.* No. 774, 68 pp.

BEAN, R. BENNETT. 1919. The weight of the leg in living men. *Amer. J. Phys. Anthrop.*, 2, 275-282.

BOWLES, GORDON T. 1932. New Types of Old Americans at Harvard and at Eastern Women's Colleges. *Cambridge:* Harvard Univ. Press, 144 pp.

BURGHARDT, W. F. 1937. A comparative anthropometric study of the colored and white male students of the State University of Iowa. Unpublished M. A. Thesis, University of Iowa. (See also, METHENY, ELEANOR. 1939. Some differences in bodily proportions between American Negro and White male college students as related to athletic performance. *Res. Quart. Amer. Assoc. Health, Phys. Educ. and Rec.*, 10, 41-53.)

CARTER, ISABEL G. 1932. Physical measurements of Old American college women. *Amer. J. Phys. Anthrop.*, 16, 497-514.

CATES, H. A., and GOODWIN, J. C. 1936. The twelve-day old baby. HUM. BIOL., 8, 433-450.

CLAPP, ANNE B. 1899. Anthropometric table of 1500 measurements of college girls at the University of Nebraska. (Reproduced by Seaver.)

COLLINS, HENRY B., Jr. 1925. Anthropometric observations on the Choctaw. *Amer. J. Phys, Anthrop.*, 8, 425-436.

————. 1928. Additional anthropometric observations on the Choctaw. *Amer. J. Phys. Anthrop.*, 11, 353-355.

DAVENPORT, CHARLES B. 1932. The growth of the human foot. *Amer. J. Phys. Anthrop.*, 17, 167-211.

————. 1938. Bodily growth of babies during the first postnatal year. *Carnegie Instit, Wash. Publ.* No. 496, *Cont. Embryol.* No. 169, 271-305.

————, and Steggerda, Morris. 1929. Race crossing in Jamaica. *Carnegie Instit. Wash. Publ.* No. 395, 516 pp.

————, ————, and Drager, William. 1934. Critical examination of physical anthropometry on the living. *Proc. Amer. Acad. Arts and Sci.*, 69, 265-284.

Dunn, Halbert L. 1923. The statics of the human arch when subjected to body weight. *Milit. Surgeon*, 52, 567-628.

Goldstein, Marcus S. 1934. Anthropometry of the Comanches. *Amer. J. Phys. Anthrop.*, 19, 289-320.

Goodman, Jack L. 1941. Physical growth of infants from birth to three months. Unpublished M. A. Thesis, Univ. of Iowa. (Also additional data not included in thesis.)

Gould, Harley N. 1936. Old Americans of the South: Anthropometry of college woman of southern birth and ancestry. *Amer. J. Phys. Anthrop.*, 21, 57-86.

————. 1941. The Acadian French in Canada and in Louisiana. *Amer. J. Phys, Anthrop.*, 28, 289-312.

Hall, (Mrs.) Winfield S. 1896. The first 500 days of a child's life. *Child-Study Monthly*, 2, 330-342.

Hall, Winfield S. 1896. The changes in the proportions of the human body during the period of growth. *J. Anthropol. Instit. Gt. Brit. and Ireland*, 25, 21-46.

Hanna, Delphine. 1894. Anthropometric table in precentile form based on measurements of 1,600 women of Oberlin College. (Reproduced by Seaver.)

Harris, Reginald G. 1926. The San Blas Indians. *Amer. J. Phys. Anthrop.*, 9, 17-63.

Hatlestad, S. Lucille. 1940. The body dimensions of college women. Unpublished study, Kansas State Teachers College.

Hitchcock, E. 1891. A comparative study of average measurements. *Proc. 6th Annual Meeting, Amer. Assoc. Adv. Phys. Educ.*, 37-42.

————. 1892. The results of anthropometry as derived from the measurements of the students in Amherst College. *Amherst, Mass:* Carpenter and Morehouse, 7 pp. (See also, Hitchcock, E., Seelye, H. H., and Phillips, P. C. 1900. An Anthropometric Manual giving physical measurements of Amherst College students between 17 and 26 years of age, and the method of securing them. *Amherst, Mass:* Carpenter and Morehouse, 40 pp. For an abridgement of part of this manual see, Hitchcock, E. 1900. Anthropometry. *Proc. 5th Annual Meeting, Amer. Assoc. Adv. Phys. Educ.*, 6-8)

————, assisted by Seelye, H. H. 1888. Statistics bearing upon the average and typical student in Amherst College, March 1888. *J. Anthropol. Instit. Gt. Brit. and Ireland*, 17, 357-358.

Hitchcock, E., Jr. 1890. A synoptic exhibit of 15,000 physical examinations. *Proc. 5th Annual Meeting, Amer. Assoc. Adv. Phys. Educ.*, 5.

Hrdlička, Aleš. 1925. The Old Americans. *Baltimore:* Williams and Wilkins,

pp. xiii, 438. (See also, HRDLIČKA, ALEŠ. 1936. Growth during adult life. *Proc. Amer. Philos. Soc.*, 76, 847-897.)

————. 1926. The Indians of Panama: Their physical relation to the Mayas. *Amer. J. Phys. Anthrop.*, 9, 1-15.

————. 1928. The full-blood American Negro. *Amer. J. Phys. Anthrop.*, 12, 15-33.

————. 1931. Anthropology of the Sioux. *Amer. J. Phys. Anthrop.*, 16, 123-170.

————. 1935. The Pueblos, with comparative data on the bulk of the tribes of the Southwest and northern Mexico. *Amer. J. Phys. Anthrop.*, 20, 235-460. (See also, HRDLIČKA, ALEŠ. 1936. Growth during adult life. *Proc. Amer. Philos Soc.*, 76, 847-897.)

ITO, PAUL K. 1936. Anthropometric study of new-born infants of Japanese parents in America. *Amer. J. Dis. Child.*, 52, 321-330.

MEREDITH, HOWARD V. 1943. Foot length in infancy, with special reference to individual differences in rate of gain and growth pattern. Unpublished study, Univ. of Iowa.

————. 1944. Growth of the young child in foot length. Unpublished study, Univ. of Iowa.

MOON, SCHUYLER B. 1896. The growth of boys. *Concord, N.H.:* Republican Press Assoc., 16 pp. (See also, Report of 10th Annual Meeting, *Amer. Assoc. Adv. Phys, Educ.*, 19-23.)

OWEN, RICHARD. 1856. A description of so-called Aztec children. *J. Ethnol. Soc. of London*, 4, 128-137.

PATEK, SADIE D. 1926. The angle of gait in women. *Amer. J. Phys. Anthrop.*, 9, 273-291.

RICHDORF, LAWRENCE F. 1925. A quantitative study of the growth of the normal infant in the first year. Unpublished Doctoral Dissertation, Univ. of Minnesota.

SARGENT, D. A. 1889. The physical development of women. *Scribner's Magazine*, 5, 172-185.

SCAMMON, RICHARD E., and CALKINS, LEROY A. 1929. The development and growth of the external dimensions of the human body in the fetal period. *Minneapolis:* Univ. Minneapolis Press, 367 pp.

SCHULTZ, ADOLPH H. 1924. Growth studies on primates bearing upon man's evolution. *Amer. J. Phys. Anthrop.*, 7, 149-164. Also SCHULTZ, ADOLPH H. 1923. Fetal growth in man. *Amer. J. Phys. Anthrop.*, 6, 389-399.

————. 1926. Anthropological studies on Nicaraguan Indians. *Amer. J. Phys. Anthrop.*, 9, 65-80.

SEAVER, JAY W. 1909. Anthropometry and Physical Examination. *New Haven:* Curtiss-Way, 191 pp.

STEGGERDA, MORRIS. 1932a. Anthropometry of adult Maya Indians: A study of their physical and physiological characters. *Carnegie Instit. of Wash., Publ.* No. 434, 113 pp. (For an extended description of the Maya communities studied, see STEGGERDA, MORRIS. 1941. Maya Indians of Yucatan. *Carnegie Instit. of Wash. Publ.* No. 531, 280 pp.

————. 1932b. Physical measurements on Dutch men and women. *Amer. J. Phys. Anthrop.*, 16, 309-337.

————. 1940. Physical measurements of Negro, Navajo, and White girls of college age. *Amer. J. Phys. Anthrop.*, 26, 417-431.

————, CRANE, JOCELYN, and STEELE, MARY D. 1929. One hundred measurements and observations on one hundred Smith College students. *Amer. J. Phys. Anthrop.*, 13, 189-254.

————, and PETTY, CHRISTINE E. 1940. An anthropometric study of Negro and White college women. *Res. Quart., Amer. Assoc. Health, Phys. Educ. and Rec.*, 11, 110-118.

————, and ————. 1942. Body measurements on 100 Negro males from Tuskegee Institute. *Res. Quart., Amer. Asso. Health, Phys. Educ. and Rec.*, 13, 275-279.

STRAUS, WILLIAM L., Jr. 1927. Growth of the human foot and its evolutionary significance. *Carnegie Instit. Wash. Publ.* No. 380, *Cont. to Embryol.*, 19, No. 101, 93-134. (See also, STRAUS, WILLIAM L., Jr. 1926. The development of the human foot and its phylogenetic significance. *Amer. J. Phys. Authrop.*, 9, 427-438.)

STREETER, GEORGE L. 1920. Weight, sitting height, head size, foot length, and menstrual age of the human embryo. *Carnegie Instit. Wash. Publ.* No. 274, *Cont. to Embryol.*, 11, No. 55, 143-170.

TALBOT, FRITZ B. 1924a. Studies in growth: I. Growth of normal children. *Amer. J. Dis. Child.*, 27, 541-550.

————. 1924b. Studies in growth: II. Growth of premature infants. *Amer. J. Dis. Child.*, 27, 550-555. (For description of sample see, TALBOT, FRITZ B, SISSON, WARREN R., MORIARTY, MARGARET E., and DALRYMPLE, ALICE J. 1923. The basal metabolism of prematurity: III. Metabolism findings in twenty-one premature infants. *Amer. J. Dis. Child.*, 26, 29-55.)

TAYLOR, ROOD. 1919. The measurements of 250 full-term infants. *Amer. J. Dis. Child.*, 17, 353-362.

TODD, T. WINGATE, and LINDALA, ANNA. 1928. Dimensions of the body: Whites and American Negroes of both sexes. *Amer. J. Phys. Anthrop.*, 12, 35-119.

WILDER, HARRIS H., and PFEIFFER, MARGARET W. 1924. The bodily proportions of women in the United States: Based upon measurements taken from one hundred Smith College students. *Proc. Amer. Acad. Arts and Sci.*, 59, 441-603. (For description of the anthropometric technique employed and a complete list of the measurement values obtained, see WILDER, HARRIS H. 1920. A Laboratory Manual of Anthropometry. *Philadelphia:* P. Blakiston's, 193 pp.)

WILLIAMS, SEYMOUR E. 1939. The anthropometric study of the feet of Negro high school boys. Unpublished M. A. thesis, Univ. of Iowa.

WOOD, M. ANNA. 1893. Anthropometric table compiled in percentile form from the measurements of 1500 Wellesley students. (Reproduced by Seaver.)

GREEK TEETH: ANCIENT AND MODERN

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ALL authorities agree that civilization has brought us nothing but woe as far as teeth are concerned. The reasons for this are far from clear and can be clarified in the present paper only by inference. This study will give evidence for the extent and timing of the changes in dental pathology from Neolithic to modern times in a single area, Greece, where the writer did field work in Physical Anthropology[1] just before the War. The evidence closely supports the hypotheses reached by Krogman[2] in his excellent discussion of the various factors influencing the appearance of caries in ancient, primitive, and civilized modern groups.

Tables 1, 3, and 4 give a general picture of the occurrence of dental pathology at various periods. The tables show that the ancient Greeks did not escape dental decay, but that it was not until the Middle Ages, several millennia after the growth of civilized urban life, that a noteworthy increase in poor dentitions occurred.

Data for ancient times are based on skulls of both sexes, and percentage frequencies of caries, loss *ante mortem*, and alveolar abscesses are based only on complete crania. For other observations and especially for frequencies of pathology relative to the total number of teeth all skulls have been used including those lacking mandibles or palates.

The average ancient Greek had teeth of good quality[3] with a medium

[1] The project was supported by travelling fellowships from Harvard, and was carried out through the help of Dr. E. A. Hooton and Dr. G. H. Chase and under the auspices of the directors of the American School for Classical Studies and of various American archaeological expeditions. The writer wishes to thank all of these individuals as well as the many Greek archaeologists, anthropologists, and officials who helped him.

[2] W. M. Krogman, 1938; see especially pp. 61-70.

[3] Teeth quality percentage frequencies: Poor, 2.67; Medium, 19.08; Good, 47.71; Excellent, 30.54; for 262 skulls. Quality is judged independently from caries frequency.

degree of wear (considerably more than modern Americans), definite traces of pyorrhea, not more than one alveolar abscess (generally periapical) of medium size, about three teeth missing, less than three of the remaining teeth definitely carious, and almost no crowding of teeth. Less than half of the ancient Greeks kept all their teeth until death or escaped alveolar abscesses, scarcely more than half escaped caries, and only a quarter escaped all three of these afflictions. The general statements of Ruffer on Egypt[4] and comparison with the various ancient groups cited by Krogman[5] suggest that the Greeks suffered from dental disease to about the same degree as other peoples of antiquity: considerably more than is generally assumed and somewhat more than primitive groups without civilized contact. Nevertheless the 17 per cent incidence of diseased teeth among ancient Greeks is less than half of that in modern urban groups, and slightly less than that among medieval Irish monks representing non-urban northwest Europeans (Table 3).

In morphology the ancient Greeks are notable for suppression of one or more third molars (generally all four) in as much as one fifth of the population. This certainly anticipates modern molar reduction, and the Greeks show also size reduction of third molars to three and four cusps for upper and lower respectively. Considerable spatulation of the upper incisors occurs in one fifth of cases, though never reaching the extreme shovel form characteristic of mongoloids.[6]

The average ancient Greek shows the following structural mouth features which may be of interest in relation to dental pathology: a broad and relatively shallow jaw with well-marked insertion rugosities for internal pterygoid and masseter muscles, broad jowls, definite though not protrusive chin, relatively broad parabolic palate, deep glenoid fossa with relatively steep slope up the articular eminence, and an occlusion pattern showing either an edge-to-edge bite or a slight overbite wearing toward an edge bite; real overbites, such as are typical of modern civilized dentitions, are not common.[7]

The contrast of modern with ancient Greek dentitions elaborated in Tables 1 and 2 is the most striking of any of the available chronological

[4] Ruffer, 1920.

[5] Krogman, 1938, pp. 52-54, Table 9.

[6] Percentage frequencies of shovel incisor development: Undeveloped, 34.58; Slight, 43.93; Medium, 21.49; Pronounced, 0; for 107 skulls.

[7] J. L. Angel, 1942, Table 1; 1944, Table 2.

TABLE 1

Contrast in dental pathology between the ancient and modern inhabitants of Greece

Character	Ancient	Modern Males	
	3300 B. C. - 1300 A. D. (both sexes)	Central Greece (urban and rural)	Chalcidice, Macedonia (entirely rural)
Teeth eruption			
Complete	71.58	83.78	100.00
M 3 suppressed	20.50	10.81	0
Incomplete	7.92	5.41	0
Individuals studied	278	37	24
Degree of teeth wear			
None to slight	33.33	43.24	8.53
Medium	41.48	43.24	20.83
Pronounced	22.96	13.52	70.84
Extreme	2.23	0	0
Individuals studied	270	37	24
Caries frequency (complete crania only)*			
None	54.93	11.11	4.17
Few (1 - 4)	42.96	50.00	25.00
Medium (5 - 8)	2.11	33.33	58.33
Many (9 - 16)	0	5.56	8.33
Very many (17 - x)	0	0	4.17
Individuals studied	142	36	24
Loss before death (crania)			
None	41.72	21.62	25.00
Few (1 - 4)	31.79	29.73	16.67
Medium (5 - 8)	12.58	21.62	16.67
Many (9 - 16)	7.29	18.92	29.16
Very many (17 - x)	6.62	8.11	12.50
Individuals available	151	37	24
Alveolar abscess presence	46.21	(67 ??)	(69 ??)
Individuals studied	145	estimate	estimate
Individuals lacking all dental pathology	25.00	2.70	4.17
Individuals studied	140	37	24

* Standards of comparison for crania and living not identical, since on the average eight teeth have been lost *post mortem* from each cranium.

TABLE 2

Contrast in masticatory morphology between ancient and modern inhabitants of Greece

Character	Ancient	Modern Males	
	3300 B. C. - 1300 A. D. (both sexes)	Central Greece (urban and rural)	Chalcidice, Macedonia (entirely rural)
Definite crowding of teeth	9.06	13.51	0
Individuals studied	265	37	23
Type of occlusion			
Underbite	0	0	4.35
Edge-to-edge bite	37.34	13.89	34.78
Overbite (sl. & full)	62.66	86.11	60.87
Individuals studied	158	36	23
Chin projection*			
Negative to small	63.69	29.73	29.17
Medium	31.84	62.16	62.50
Marked	4.47	8.11	8.33
Individuals studied	179	37	24

* Standards of comparison for skeleton and fleshy chin probably not identical.

comparisons. Of the two small series of living Greek males the Macedonian one comes from an entirely rural farming population which underwent many privations during the first War, and hence is not strictly comparable with the predominantly urban ancient series. In age and in environmental background the Central Greek group[8] is more like the ancient series than are the Macedonians.

As seen in Tables 1, 2, and 4 modern Greeks contrast with their ancestors in showing less teeth wear (except for the rural Macedonians), a double incidence of caries and teeth loss, more overbites with slightly more crowding (except Macedonians) and more projecting chins: dental deterioration accompanied by a weaker occlusion type.

As seen in Tables 3 and 4 there are no ancient trends toward this recent deterioration. But the tables show at least four interesting changes in dental pathology.

[8] From Doris and Phocis, Boeotia and Megaris, Attica, Corinth, Peloponnese, and Ionian islands.

(1) It is surprising that the entirely rural pre-Greek farming, hunting, and sea-fishing population of the third millennium B. C. should show higher caries frequency than Greeks as a whole. It is conceivable that because of younger age at death a certain percentage of teeth which would have fallen out in later times remained merely carious. But osteoporotic pitting of orbital roofs and sometimes of parietals and occipital occurs in about one fifth of Early Helladic skulls, not recurring until Medieval times. And it is possible that dietary insufficiencies affected also the teeth of these first farmers in Greece.

(2) Cephallenians of Submycenaean date show excessive dental pathology which might be linked with their insular inbreeding.[9] But the excess of diseased teeth occurs entirely in a few old or middle-aged males who overweight the small sample since they are more complete than the bulk of younger skulls. Cephallenian teeth are good in quality and probably little more diseased than in contemporaneous and slightly later Early Iron Age[10] populations of Central Greece.

(3) As seen most clearly in Table 4 a rise in dental pathology accompanies increasing "urbanisation" from 2000 B. C. through the confused and vigorous Early Iron Age.[11] But there is an apparent decrease in pathology during Classical and Roman periods of complete urbanization in spite of an increase in age at death. In fact the frequency of individuals with perfect dentitions increases at this time (Table 3). This should effectively contradict the idea that urban civilization by itself is responsible in some mysterious way for dental decay.[12]

(4) Dental pathology in Byzantine times scarcely anticipates at all the deterioration occurring after 1300 A. D. In the data quoted in Table 4 Dr. A. Krikos[13] apparently exaggerates caries frequency probably (as a dentist) considering carious those teeth which would have

[9] J. L. Angel, 1943, p. 251.

[10] Submycenaean, Protogeometric, and Geometric periods combined.

[11] This might also tend to confirm Vallois' guess that use of new metals favors production of dental decay. H. V. Vallois, 1939.

[12] As Krogman also concludes. W. M. Krogman, 1938, pp. 69-70, 63.

[13] A. Krikos, 1935. This Greek investigator was the first to lament the poor condition of dentitions in modern Greece, pointing out an apparently definite trend in this direction in late Byzantine times climaxing a very slight increase in caries during ancient times as a whole. The present writer fails to confirm this last finding of Krikos, made on less material than available in 1938.

TABLE 3

Chronological changes in percentage of individuals with various dental pathologies among Ancient Greeks (both sexes combined), and other masticatory features, with an additional comparison with a series of medieval monks from Central Ireland, published by W. W. Howells, and averaging 10 to 15 years older at death than the Ancient Greeks.

Character	Neolithic & Early Bronze Before 3000 - ca. 2000 B. C.		Middle Bronze (M.H. & L.H. II) ca. 2000 - 1400 B. C.		Mycenaean (L. H. III) Before 1400 - ca. 1150 B. C.		Submycenaean Cephallenia Before 1200 - ca. 1000 B. C.		Early Iron Age Before 1150 - 650 B. C.		Classic to Hellenistic 650 - 150 B. C.		Roman 150 B. C. - ca. 450 A. D.		Byzantine to Medival ca. 450 - 1300 A. D.		Total Of All Periods In Ancient Greece (both sexes)		Medieval Irish Monks, Gallen ca. 600 - 1600 A. D.	
Suppression of third molar	17.86		29.03		15.00		0		10.26		27.87		28.57		25.93		20.50		8.0	
Number skulls		28		31		40		18		39		61		28		27		278		87
Mean cusp number of M 3																				
Upper	3.0		3.1		3.3		3.4		3.2		3.0		2.8		3.3		3.1		3.1	
Number skulls		6		17		17		7		19		25		16		9		116		20
Lower	4.6		4.2		3.9		4.0		4.2		4.3		4.2		4.2		4.2		4.4	
Number skulls		9		18		11		2		23		22		9		9		103		22
Degree of teeth wear																				
None to slight	25.00		27.27		37.50		40.00		34.21		37.74		33.33		25.00		33.33		4.5	
Medium	57.14		45.45		35.00		40.00		34.21		33.33		44.44		53.57		41.48		25.0	
Pronounced	14.29		27.27		25.00		15.00		23.68		25.93		22.22		21.43		22.96		64.3	
Extreme	3.57		0		2.50		5.00		7.86		0		0		0		2.23		6.2	
Number skulls		28		33		39		20		38		54		27		28		270		112
Poor to medium teeth quality	21.43		21.88		30.77		5.00		32.44		12.50		14.29		32.14		21.75		58.9	
Number skulls		28		32		39		20		37		48		28		28		262		95
Caries frequency (in complete crania only)*																				
None	50.00		54.17		54.15		20.00		54.84		62.96		64.29		50.00		54.93		69.8	
Few (1 - 4)	41.67		46.66—		45.45		80.00		45.16		37.04		28.57		50.00		42.96		29.2	
Medium (5 - 8)	8.33		4.17		0		0		0		0		7.14		0		2.11		1.0	
Number crania		12		24		11		5		31		27		14		16		142		96
Loss before death (crania)																				
None	27.27		51.85		40.00		20.00		40.63		33.33		57.14		50.00		41.53		27.5	

Number crania		12		24		11		5		31		27		14		16		142		90
Loss before death (crania)																				
None	27.27		51.85		40.00		20.00		40.63		33.33		57.14		50 00		41.72		27.6	
Few (1 - 4)	36.36		22.22		40.00		20.00		21.88		47.06		42.86		25.00		31.79		42.9	
Medium (5 - 8)	9.09		18.52		20.00		20.00		18.75		9.09		0		12.50		12.58		15.2	
Many (9 - 16)	27.27		7.41		0		0		6.25		3.03		0		18.75		7.29		14.3	
Very many (17 - x)	0		0		0		40.00		12.50		6.06		0		0		6.62			
Number crania		11		27		10		5		32		33		14		16		151		105
Alveolar abscess presence	63.64		39.13		27.27		60.00		53.13		46.67		42.86		43.75		46.21		45.2	
Number crania		11		23		11		5		32		30		14		16		145		93
Crania lacking dental pathology (caries, loss, abscesses)	9.09		21.74		20.00		0		22.58		29.63		42.86		31.25		25.00		(25.4 ??)	
Number crania		11		23		10		5		31		27		14		16		140		estimate
Presence of pyorrhea	65.38		56.52		52.63		55.56		51.43		50.98		85.19		48.28		57.71		31.0	
Number skulls		26		23		38		18		35		51		27		29		253		87 ..
Definite crowding of teeth	20.00		10.00		2.70		5.26		5.56		7.55		10.71		14.29		9.06		14.1	
Number skulls		30		30		37		19		36		53		28		28		265		64
Type of occlusion																				
Edge-to-edge bite	47.06		44.00		31.58		11.11		50.00		34.62		18.75		37.50		37.34		37.3	
Slight overbite	47.06		36.00		68.42		66.67		40.00		50.00		50.00		31.25		46.84		54.2	
Full overbite	5.88		20.00		0		22.22		10.00		15.38		31.25		31.25		15.82		8.5	
Number skulls		17		25		19		9		30		26		16		16		158		59
Articular eminence slope																				
Slight (flat)	6.90		9.68		7.94		16.13		5.41		7.58		9.38		5.26		8.06		.8	
Medium	58.62		58.06		44.44		38.71		54.05		39.39		29.03		39.47		44.18		28.5	
Steep	34.48		32.96		47.62		45.16		40.54		53.03		62.50		55.2C		47.76		70.7	
Number skulls		29		31		63		31		37		66		32		38		335		123
Chin projection																				
Negative	0		4.00		0		0		5.56		0		0		0		1.67		0	
Neutral	30.43		16.00		21.43		14.29		27.78		33.33		14.29		5.26		22.91		8.6	
Small	34.78		56.00		21.43		42.86		41.67		33.33		42.86		42.11		39.11		37.5	
Medium	30.43		24.00		57.14		14.29		19.44		28.21		35.71		52.63		31.84		47.1	
Pronounced	4.35		0		0		28.27		5.56		5.13		7.14		0		4.47		6.7	
Number jaws		23		25		14		7		36		39		14		19		179		104

* On the average eight teeth have been lost *post mortem* from each complete cranium.

TABLE 4

Frequency of loss before death, caries, and alveolar abscesses relative to total possible and actual number of teeth among Greek populations of Ancient to modern times. *

Period Group	Total Number Teeth Possible	Loss Before Death		Actual Number	Caries			Carious Plus Lost Teeth		Alveolar Abscess Frequency		Mean
		Number lost	% of possible	Teeth Preserved	Number carious	% of actual	% of possible	Number	% of possible	No.	% of possible	Age In Years
Total Ancient Greek series	6550	852	13.0	3656	251	6.9	3.9	1103	16.9	207	3.2	35.6
Neolithic-E. H. 3rd mill. B. C.	570	62	10.9	267	32	12.0	5.6	94	16.5	20	3.5	32.2
Middle Bronze 2000-1400 B. C.	848	70	8.5	601	34	5.7	3.8	104	12.3	20	2.4	34.7
Mycenaean 1400-1150 B. C.	807	116	14.4	356	22	6.2	2.7	138	17.1	19	2.4	34.0
Cephallenia 1200-1000 B. C.	380	72	18.4	180	28	15.6	7.9	100	26.3	13	3.4	36.4
Early Iron Age 1150-650 B. C.	1098	179	16.3	724	40	5.5	3.6	219	19.9	42	3.8	35.1
Classic 650-150 B. C.	1351	157	11.6	724	36	5.0	2.7	193	14.3	43	3.2	38.2

Period Group	Total Number Teeth Possible	Loss Before Death		Actual Number	Caries			Carious Plus Lost Teeth		Alveolar Abscess Frequency		Mean
		Number lost	% of possible	Teeth Preserved	Number carious	% of actual	% of possible	Number	% of possible	No.	% of possible	Age In Years
Classic 650-150 B. C.	1351	137	11.3	724								
Roman 150 B.C.-450 A.D.	656	46	7.0	363	29	8.0	4.4	75	11.4	26	4.1	36.5
Byzantine 450-1300 A .D.	697	86	12.3	419	26	6.2	3.8	112	16.1	22	3.3	34.3
Turkish-recent A. Krikos' data 1300-x A. D.	4830	1029	21.3	3801	1008	26.5	20.9	2037	42.2	—	—	41 ?
Modern males:												
Central Greece Living in 1939	1160	228	19.7	932	148	15.9	12.7	376	32.4	—	—	37.0
Chalcidice, Macedonia	768	192	25.0	676	146	21.6	19.0	338	44.0	—	—	37.9

* Note: Teeth of both sexes have been used for calculating the frequencies of dental pathology from the cranial series. Age at death was estimated from ectocranial suture closure according to the criteria of Todd and Lyon, and the means for each sex were averaged to obtain the values listed here.

needed preventive filling as well as those with manifest caries. But it is still possible, as the Macedonian series might suggest, that dental pathology during the period of Turkish occupation exceeded that in modern Greece.

In contrast to the minor fluctuations in pathology, mechanical details of the masticatory apparatus do show some valid trends during ancient times anticipating modern masticatory reduction. A tendency toward increasingly definite overbites especially during the historic period shows a coefficient of mean square contingency (C) with period of .33, though χ^2 is not quite significant. Steepening of the slope of the articular eminence accompanies this change ($C = .20$), and is constant from Neolithic to Byzantine times though not satistically significant. Increasing shallowing and projection of chin occurs during historic times, the former being significant[14] and the latter showing a C with period of .33, though not significant. Possible tendencies occur toward cusp reduction and especially suppression of third molars. And a chronological increase in teeth crowding is possible.

These minor trends probably result as a group from a gradually increasing use of a "civilized" diet lacking tough foods more than from genetic recombinations ("evolutionary forces"). And since these incipient changes appear to form a complex of masticatory (not dental) weakening or reduction a tempting explanatory hypothesis presents itself. Increasing urbanization can hardly be the cause of dental deterioration during the Turkish occupation. Perhaps masticatory reduction is a cause.[15]

This hypothesis is worth testing by inquiring how far in the ancient material dental pathology is associated with the details of mouth construction mentioned above. Jaw and palate morphology and also resistance to dental disease[16] depend largely or partially on heredity. Considerable genetic (racial) changes took place in Greece during the poorly known interval from 1300 A. D. to the present day, continuing the directions of change already well established in ancient times.[17] Hence the associations with race must also be tested for tooth pathology and for the above hypothesis.

[14] J. L. Angel, 1944, Table 8.

[15] As well as the obvious deterioration in hygienic living conditions which was already in progress in Byzantine times.

[16] C. E. Keeler, 1935.

[17] J. L. Angel, 1944.

Type of occlusion, or "bite," serves as the key to classification of individual variants in use of jaws and teeth. Observation of wear of teeth surfaces and of mouth action of primitive people or others with edge bites makes clear that an edge bite tends to go with a rotary and relatively horizontal jaw motion. Among civilized peoples a definite overbite accompanies a more vertical jaw motion with diagonal rather than lateral side excursions limited by the degree of incisor and canine overlap. Slight overbites appear intermediate. It is at once obvious that type of bite may change with age, individuals with slight overbites in youth acquiring edge bites as their teeth wear down or especially with a "civilized" diet without tough food developing rapidly a marked degree of overbite which will inhibit teeth wear and vigorous mastication. These tendencies are suggested by a multiple association table of teeth wear, bite, age at death, and articular eminence slope. Hence bite shows a significant and strong association with teeth wear ($C = .43$) since only with a functional edge bite and mainly lateral chewing motion is any great degree of wear possible.[18] The obvious linkage of teeth wear with age ($C = .51$) probably determines the association of bite with age ($C = .35$, on borderline of significance), since individuals with marked overbites and the accompanying slight teeth wear, whose excess would eliminate this association, are rare at all ages among *ancient* Greeks.

Since steepness of slope of articular eminence of the jaw joint must be closely linked functionally with chewing, its definite steepening with age ($C = .26$, χ^2 significant), with teeth loss ($C = .32$, χ^2 on borderline of significance), and with teeth wear ($C = .29$, χ^2 probably significant) is natural and actually less clearcut than expected. Logically, development of an edge bite (with increasing age and wear and loss of teeth) should go with steepening of the path of the mandibular condyle. But this association does not exist ($C = .15$, χ^2 not significant), probably because steepening of articular eminence slope occurs both with edge bite development and with definite overbites, plausibly depending on the changed plane of chewing and changed external pterygoid muscle action which must accompany any decrease in distance between the anterior alveolar borders no matter what its cause.

Except for those directly dependent on age no further associations of masticatory or dental traits with bite are demonstrable. Linkage be-

[18] Note the cross contrasts in bite and wear between modern Central Greeks and rural Macedonians.

tween bite and teeth quality ($C = .32$, χ^2 significant) in which medium and poor quality teeth group with edge bites, is an obvious age effect. Parallel tendencies in teeth loss and caries are not significant.

Thus although the mechanical factors studied and dental pathologies show complicated associations with each other these obviously depend on age and teeth wear,[19] since the only strong associations are with these two variables. In this connection the lack of association between bite and articular eminence slope, teeth loss, and caries is striking. Is it possible that elimination of the age change factor would reveal an opposite association, between overbites with restricted jaw motion, steep articular eminence, and increased dental decay?[20] This question cannot be answered from present data, and among ancient Greeks dental pathology must be considered statistically independent of mechanical factors.

A similar lack of simple trends marks the statistically significant mechanical and morphological dental characters in each of the six morphological types determined for the heterogeneous ancient Greeks as representing the chief "racial" deviations from the average stereotype.[21] In the rugged, long-headed, and coarse-faced Basic White type a lack of pyorrhea and unreduced lower third molars go with strong chin, large U palate form and rugged jaw beneath short upper face. In the delicate Mediterranean with its steep forehead and pinched face an overbite goes with the expected slight teeth wear, weak and small jaws, and shallow and pointed chin. In the horse-faced Nordic-Iranian long-heads reduction of upper third molars illogically accompanies a steep articular eminence slope (with strong postglenoid process) and sharply etched insertions of masseter and internal pterygoid muscles which help move the large and broad-jowled jaw under the long and high palate. Reduction in caries and teeth loss, improved teeth quality, relatively slight articular eminence slope, and medium crowding occur

[19] The writer is aware of the impossibility of deducing causes from correlations alone and bases conclusions on common sense as much as the uniformly low coefficients of mean square contingency.

[20] The 24 ancient Greek crania with fully developed overbites show steep articular eminence slopes despite their relative youth which in turn appears to determine their relatively good teeth. But in a population with overbite dominance and non-stimulating diet it seems possible that weakening of the chewing mechanism might predispose to caries and loss, in contrast to these 24 crania. Compare W. M. Krogman, 1938, p. 63.

[21] J. L. Angel, 1942, Table 1; 1943, pp. 232-234; 1944, Tables 3-4.

together in the Dinaric-Mediterranean hexagonal-faced mesocephalic type with its high face, high palate, and significantly younger than average age at death. The mesocephalic Mixed Alpine type shows no dental peculiarities. But in the round-headed, squat-faced, thick-nosed Alpines occurs an edge bite with marked teeth wear, poorer than average teeth quality, more loss, lack of shovel incisors, prominent chin, and short and low palate with retracted alveolar borders and wide facial architecture, but with only a slight and statistically insignificant increase in age at death over that of the total series. Poorness of Alpine teeth obviously centres on their excess wear, probably related to genes (if at all) through their facial structure rather than directiy.

It is notable that excess dental pathology is not here linked with the weak-jawed Mediterranean type as might be expected but with the wide-mouthed Alpine type. Since the general trend in Greece from the third millennium B. C. onward has been in an Alpine direction (though with considerable Dinaric tendencies after the Classic period) it is just possible that genetic (racial) factors may play a rôle, extremely limited, in increase of dental decay after 1300 A. D. This is uncertain because of the obvious artificial fixity of any "type." Dental pathology in ancient Greece is not influenced by race mixture,[22] since the phases of striking racial heterogeneity, Middle Bronze, Early Iron, and Roman-Byzantine periods,[23] show no uniformity in disease frequency. Hence the importance of heredity in dental deterioration appears restricted.

Similarly the development of a weak masticatory apparatus with marked overbite can play only a minor rôle in determining the late Medieval dental deterioration, since the testing of this hypothesis was inconclusive and the racial evidence just covered does not support it.

Extrinsic factors, therefore, must be almost entirely responsible for the rise in dental pathology in Greece. Urbanization *per se* has been shown above to improve rather than to destroy the dentition. And it is therefore in those peripheral features of urban civilization which occur in Medieval Greece but not in Classical or Roman times that the major causes for dental decay must lie. Population overcrowding may be the key, since, although the Byzantine population had shrunk since Classical times, the modern population of Greece is almost triple that of Classical

[22] W. M. Krogman, 1938, p. 66, agrees with this from other data.

[23] J. L. Angel, 1944, Tables 8-9.

times.[24] Certainly the effects of deforestation, erosion,[25] soil impoverishment, and generally less hygienic living conditions on diet and especially on its vitamin and mineral salt content[26] must be major factors. But with present data it is impossible to work out the interrelationships of these environmental features with dental decay in such a way as to test this conclusively. Although living conditions during the later Middle Ages in Greece and elsewhere were certainly worse than in Classical times there is no evidence that modern Greeks (except for Macedonians) in 1939 were receiving a less adequate diet than Classical Greeks. One is tempted to infer that increase in the actual organisms of decay, possibly coupled with a great increase in sugar content of the diet, are the chief direct causes of the modern Greek dental deterioration, together with the very minor racial and mechanical factors and against a background of overcrowding and soil impoverishment. Both poor environmental conditions and the racial and mechanical factors considered had been in operation for many generations before the marked increase in dental pathology.

SUMMARY

(1) Ancient Greeks, with 17 per cent of all teeth affected by decay and only 25 per cent of the population exempt from it, enjoyed the popularly supposed immunity from dental disease no more than other peoples of antiquity, but had better teeth than modern civilized peoples.

(2) A slight trend toward poor teeth from 2000 to about 600 B. C. cannot be connected with urban civilization's rise since teeth improved under full urban conditions of Classical and Roman times and marked deterioration does not occur until after 1300 A. D.

(3) Relatively good teeth in ancient Greece accompany vigorous chewing mechanisms and poor modern teeth occur with frequent definite overbites, slightly more crowding, and more projecting chins.

(4) Among ancient Greeks no association between definite overbites and decayed teeth is demonstrable: teeth wear and age processes dominate both dental decay and chewing mechanism changes.

(5) Genetic (racial) factors possibly play a part, strictly limited, in the incidence of dental decay: the Alpine type shows relatively poor teeth, with excess of loss, wear, and edge bites.

[24] H. Michell, 1940, p. 19.
[25] E. Huntington, 1910, pp. 666, 668, 672.
[26] W. M. Krogman, 1938 pp. 61-62.

(6) Since mechanical and racial factors can play only extremely insignificant parts in increase of dental pathology this must result from changing environment, both social (overcrowding) and dietary (soil exhaustion, excess sugar).

(7) There is marked lag between the appearance of these environmental, mechanical, and racial factors and the eruption of late medieval and modern dental deterioration.

BIBLIOGRAPHY

ANGEL, J. L. 1942. Classical Olynthians. Appendix on skeletal material in D. M. Robinson "Excavations at Olynthus, Part XI, Necrolynthia," *Baltimore*, pp. 211-240.

————. 1943. Ancient Cephallenians. *Am. Journ. Phys. Anthrop., N.S.* vol. 1, pp. 229-260.

————. 1944. A racial analysis of the ancient Greeks. *Am. Journ. Phys. Anthrop., N.S.* vol. 2, No. 4.

HOWELLS, W. W. 1941. The Early Christian Irish: the skeletons at Gallen Priory. *Proc. of the Royal Irish Acad.* vol. 46, Section C, No. 3, *Dublin.*

HUNTINGTON, E. 1910. The burial of Olympia. *Geogr. Journ., London,* vol. 36, pp. 657 ff.

KEELER, C. E. 1935. Heredity in dentistry. *Dental Cosmos,* Dec. pp. 1147-1163.

KRIKOS, A. 1935. The development of dental caries in Greece from the most ancient to modern times (in Greek). *Proc. of Greek Anthrop. Soc.*, vol. 12, pp. 3-18.

KROGMAN, W. M. 1938. The rôle of urbanization in the dentitions of various population groups. *Zeitschr. f. Rassenkunde,* vol. 7, pp. 42-72.

MICHELL, H. 1940. "The economics of ancient Greece." *Cambridge.*

RUFFER, *Sir* A. 1920. Study of abnormalities and pathology of ancient Egyptian teeth. *Am. Journ. Phys. Anthrop.*, vol. 3, pp. 335-382, Plates I-VIII.

TODD, T. W., and LYON, D. W. 1924. Endocranial suture closure, its progress and age relationship. Part 1. Adult males of white stock. *Am. Journ. Phys. Anthrop.*, pp. 325-384.

VALLOIS, H. V. 1939. Les ossements humains de Sialk. *In* R. Girshman "Fouilles de Sialk 1933, 1934, 1937," vol. 2. Louvre Dept. des Antiqu. Orient., Sér. Arch., vol. 5, *Paris,* pp. 113-192.

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HOWELL, A. BRAZER. Speed in Animals—Their Specialization for Running and Leaping. *Chicago* (Univ. Chicago Press), 1944. Pp. xii + 270. 9 × 6 inches. $4.00. ["Literature Cited" of 5⅛ pages.]

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KROEBER, A. L. Peruvian Archeology in 1942. *Viking Fund Publications in Anthropology Number Four. New York* (The Viking Fund), 1944. Pp. 151 + 48 plates. 10 × 6⅞ inches. $3.00 (paper). [Bibliography of 2 pages.]

MEYEROWITZ, EVA L. R. Ibeji statuettes from Yoruba, Nigeria. *Man*, 44: 105-107 + 1 plate, 1944. [6 bibliographic footnotes.]

YALE PUBLICATIONS IN ANTHROPOLOGY. Containing the following papers: No. 30. Archeological Regions of Colombia: A Ceramic Survey, by WENDELL C. BENNETT. Pp. 120 + 12 plates. No. 31. Excavations in the Vicinity of Cali, Columbia, by JAMES A. FORD. Pp. 79 + 4 plates. 9¾ × 7 inches. Bound under one cover and sold as a unit for $2.50 (paper).

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ENGARD, CHARLES J. Organogenesis in *Rubus*. *University of Hawaii Research Publication No. 21*. *Honolulu* (Univ. of Hawaii), 1944. Pp. xvi + 234. 9 × 6 inches. [Bibliography of 8 pages.]

RIDDLE, OSCAR, and W. F. HOLLANDER. "Scraggly" plumage and ataxia: two inherited characters in the pigeon. *J. Hered.*, 34: 167-171, 1943. [Bibliography of 8 titles.]

SCHRADER, FRANZ. Mitosis. The Movements of Chromosomes in Cell Division. *New York* (Columbia Univ. Press), 1944. Pp. 110. 9 × 6 inches. $2.00. [Biliography of 18 pages.]

5. *Human Heredity*

ALLEN, WILLIAM, and C. NASH HERNDON. Ritinitis pigmentosa and apparently sex-linked idiocy in a single sibship. *J. Hered.*, 35: 41-43 + 1 figure, 1944. [Bibliography of 5 titles.]

KALLMAN, FRANZ J., and DAVID REISNER. Twin studies on genetic variations in resistance to tuberculosis. *J. Hered.*, 34: 269-301, 1943. [Bibliography of 31 titles.]

KALLMAN, FRANZ J., WILLIAM A. SCHOENFELD, and S. EUGENE BARRERA. The genetic aspects of primary eunuchoidism. *Am. J. Ment. Defic.*, 48: 203-236, 1944. [Bibliography of 48 titles.]

6. *Eugenics*

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1. *Environment of Man*

AMERICAN WILDLIFE INSTITUTE. The Wolves of North America. Part I. Their History, Life Habits, Economic Status, and Control, by STANLY P. YOUNG. Part II. Classification of Wolves, by EDWARD A. GOLDMAN. *Washington, D.C.* (Am. Wildlife Inst.), 1944. Pp. xx + 636. 9⅝ × 6 inches. $6.00. ["References and Selected Bibliography" of 80 pages.]

BATES, MARSTON. Observations on the distribution of diurnal mosquitoes in a tropical forest. *Ecology*, 25: 159-170, 1944. [Bibliography of 15 titles.]

BOWERMAN, MARY L. The Flowering Plants and Ferns of Mount Diablo, California: Their Distribution and Association into Plant Communities. *Berkeley* (Gillick Press), 1944. Pp. viii + 290. $3.75. ["Literature Cited" of 6 pages.]

COOLEY, R. A., and GLEN M. KOHLS. The Argasidae of North America, Central America and Cuba. *The Am. Midland Naturalist, Monograph No. 1. Notre Dame, Indiana* (The University Press), 1944. Pp. 152. 9⅛ × 6 inches. $2.00. [Bibliography of 5 pages.]

EVANS, H. MUIR. Sting-fish and Seafarer. *London* (Faber and Faber), 1943. Pp. 180. 9 × 5¾ inches. 15s.

GRAHAM, VERNE OVID. Mushrooms of the Great Lakes Region. The Fleshy,

Leathery, and Woody Fungi of Illinois, Indiana, Ohio, and the Southern Half of Wisconsin and of Michigan. *Chicago Academy of Sciences Special Publication No. 5. Chicago.* Pp. viii + 390 + 49 plates. 9½ × 6-3/5 inches. $4.10 (paper).

GRIGSON, GEOFFREY. Wild Flowers in Britain. *London* (William Collins), 1944. Pp. 48 + 12 colored plates. 8¾ × 6¼ inches. 4s 6d.

HAGELSTEIN, ROBERT. The Mycetozoa of North America Based upon the Specimens in the Herbarium of the New York Botanical Garden. *Mineola, N. Y.* (Robert Hagelstein), 1944. Pp. 306 + 16 plates. $6.00.

HARTNACK, HUGO. Unbidden House Guests. *Tacoma, Wash.* (Hartnack Publ. Co.), 1943. Pp. 560 (?). 9 × 6 inches. $12.00.

LANE, J., and L. WHITMAN. Novas espécies de culex do Brasil *(Diptera, Culicidae). Rev. de Entomologia,* 14: 389-408, 1943. [Bibliography of 8 titles.]

LUNDELL, CYRUS LONGWORTH, and Collaborators. Flora of Texas. Vol. 3, Pt. 2. Anacordiaceae, by FRED A. BARKLEY; Cyrillaceae, Aquifoliaceae, by CYRUS LONGWORTH LUNDELL; Convolvulaceae, genus *Cuscuta,* by TRUMAN G. YUNCKER. *Dallas* (Southern Methodist Univ. Press), 1943. Pp. 89-150. 10¼ × 7 inches. $1.50 (paper).

LUNDELL, CYRUS LONGWORTH, and Collaborators. Flora of Texas. Vol. 3, Pt. 3. Orchidaceae, by DONOVAN S. CORRELL. *Dallas* (Southern Methodist Univ. Press), 1944. Pp. 151-196 + 34 plates. 10¼ × 7 inches. $3.00 (paper).

MORRIS, PERCY A. They Hop and Crawl. *Lancaster* (Jaques Cattell Press), 1944. Pp. ix + 253. 9-1/9 × 6 inches. $3.50.

WAKSMAN, SELMAN A., H. SCHULHOFF, C. A. HICKMAN, T. C. GORDON, and S. C. STEVENS. The Peats of New Jersey and Their Utilization. *Dept. Conservation and Development, State of New Jersey in cooperation with New Jersey Agricultural Experiment Station, Rutgers Univ. Bull.* 55-Pt. B, *Geologic Series. Trenton,* 1943. Pp. 278. 9 × 6 inches (paper). [Bibliography of 110 titles.]

2. *Public Health and Hygiene*

BEVIER, GEORGE. Some international aspects of yellow fever control. *Brit. Guiana Med. Ann.,* 1943. Pp. (of reprint) 21. [Bibliography of 26 titles.]

BURNETT, R. WILL. To Live in Health. *New York* (Duell, Sloan and Pearce), 1944, Pp. vii + 332. 9¼ × 6⅛ inches. $2.75. [List of "Further Readings" of 6½ pages.]

CAMERON, THOMAS W. M. The Parasites of Man in Temperate Climates. *Toronto* (Univ. of Toronto Press), 1942. Pp. xi + 182. 9 × 6 inches. $3.00. [Bibliography of 2 pages.]

CARTER, H. R. Malaria—Lessons on Its Cause and Prevention for Use in Schools. *Pub. Health Rep., Supplement No.* 18. Rev. by L. I. Williams, Jr., *Washington* (Govt. Printing Office), June 28, 1943. Pp. 23. 9⅛ × 5⅞ inches. 10 cents (paper).

CHOPE, HAROLD D. The case method in teaching public health administration. *Am. J. Pub. Health,* 34: 605-610, 1944. [Bibliography of 3 titles.]

COFFEY, E. R. Planning for health education in the war and post-war periods—the national program. *Pub. Health Rep.,* 59: 897-904, 1944.

HERMS, WILLIAM B., and HAROLD F. GRAY. Mosquito Control: Practical Methods for Abatement of Disease Vectors and Pests. 2d ed., revised and enlarged. *New York* (Commonwealth Fund), 1944. Pp. xiv + 419. 9¼ × 6⅛ inches. $3.50. [Bibliography for each chapter.]

KNIPE, FRED W. Agricultural engineers in malaria research and control. *Agricultural Engineering*, 25: 217-219, 1944.

MUSTARD, HARRY S. An Introduction to Public Health. 2d ed. *New York* (Macmillan Co.), 1944. Pp. 283. 8-3/5 × 5½ inches. $3.25. ["References" for each chapter.]

ORR, *Sir* JOHN BOYD, and FRANK WELLS. Housing and Health. Design for Britain (Second Series). *London* (J. M. Dent and Sons, Ltd.), 1944. Pp. 31. 8½ × 5½ inches. 6d.

SAWYER, WILBUR A. International health. *Bull. N. Y. Acad. of Med.*, Sec. Ser.; 20: 394-410, 1944.

TURNER, C. E. Personal and Community Health. Seventh edition. *St. Louis* (C. V. Mosby Co.), 1943. Pp. 585. 8½ × 5⅜ inches. $3.50. [List of references for each chapter.]

WHITLOCK, OLIVE M., VICTORIA M. TRASKO, and F. RUTH KAHL. Nursing Practices in Industry. *Pub. Health Bull. No. 283. Washington* (Govt. Printing Office), 1944. Pp. iv + 70. 9⅛ × 5⅞ inches. 5 cents. [Bibliography of 6½ pages.]

WINSLOW, C. -E. A. International Organization for Health. *New York* (Commission to Study the Organization of Peace), 1944. Pp. 32. 8¼ × 5½ inches. 10 cents.

WOLMAN, ABEL, ALFRED H. FLETCHER, and WILMER H. SCHULZE. Favorable and adverse developments in the school environment. *Am. J. Pub. Health*, 34: 484-488, 1944.

WRIGHT, WILLARD H. The Bedbug—Its Habits and Life History and Methods of Control. *Supp. to Pub. Health Rep.* No. 175. *Washington* (Govt. Printing Office), 1944. Pp. 9 + 2 plates. 9⅛ × 5⅞ inches. 5 cents. [1 bibliographic footnote.]

3. *Migration*

TAYLOR, GRIFFITH. Environment, Race and Migration. Fundamentals of Human Distribution; with Special Sections on Racial Classification; and Settlement in Canada and Australia. *Toronto* (Univ. of Toronto Press), 1937. Pp. xv + 483. 9⅛ × 6¼ inches. $3.50. [Bibliographic footnotes throughout.]

4. *Population*

BUREAU OF THE CENSUS. *Population—Special Reports. Washington, D.C.* Marriages in the United States: 1914 to 1943. Series PM-1, No. 1. July 4, 1944. Pp. 2.

BUREAU OF THE CENSUS. *Population—Special Surveys. Washington, D.C.* Marital status of the civilian population: February, 1944. Series P-S, No. 1. June 20, 1944. Pp. 3.

BUREAU OF THE CENSUS. *Population—Special Reports. Washington, D.C.* Nor-

mal growth of the labor force in the United States: 1940 to 1950. Series P-44, No. 12. June 12, 1944. Pp. 4.

13. State of birth of the native population: 1940. June 24, 1944. Pp. 7.

14. Estimated population in continental United States excluding armed forces overseas, by months: May 1, 1940, to July 1, 1943. June 26, 1944. Pp. 2.

15. Estimated civilian population, by age and sex, for selected areas: November 1, 1943. July 1, 1944. Pp. 9.

16. Estimated population in continental United States, by regions, divisions, and states: July 1, 1943. July 12, 1944. Pp. 2.

17. Interstate migration and other population changes: 1940 to 1943. Aug. 28, 1944. Pp. 5.

18. Provisional estimates of the population 21 years old and over for the United States, by states: Nov. 1, 1943. Aug. 29, 1944. P. 1.

DAVIS, KINGSLEY. Demographic fact and policy in India. *Milbank Mem. Fd. Quart.*, 22: 256-278, 1944. [Some bibliographic footnotes.]

JURKAT, ERNEST. Prospects for population growth in the Near East. *Milbank Mem. Fd. Quart.*, 22: 300-317, 1944. [1 bibliographic footnote.]

MOORE, WILBERT E. Agricultural population and rural economy in eastern and southern Europe. *Milbank Mem. Fd. Quart.*, 22: 279-299, 1944. [Some bibliographic footnotes.]

TAEUBER, IRENE B., and EDWIN G. BEAL. The dynamics of population in Japan. *Milbank Mem. Fd. Quart.*, 22: 222-255, 1944. [25 bibliographic footnotes.]

TRUESDELL, LEON E. [Prepared under the supervision of]. Population: Families, Size of Family and Age of Head, Regions and Cities of 1,000,000 or More. *Washington* (Govt. Printing Office), 1944. Pp. iv + 127. 11¾ × 9 inches. 30 cents.

5. *Mortality and General Vital Statistics*

BUREAU OF THE CENSUS. *Vital Statistics—Current Mortality Analysis. Washington, D.C.* Discussion of returns from the mortality sample. Vol. 2. No. 4. Apr., June 26. No. 5. May, July 25. No. 6. June, Aug. 26.

BUREAU OF THE CENSUS. *Vital Statistics—Special Reports. Washington, D.C.* Various numbers of Volume 19, Selected Studies, as follows:

14. Comparison of cause of death assignments by the 1929 and 1938 revisions of the International List deaths in the United States, 1940. Pp. 154-277.

16. The birth registration system of Canada. Pp. 289-337.

17. Live births by age of mother, United States and each state, 1942. Pp. 339-350.

19. Deaths and death rates for selected causes by age, race, and sex, United States, 1942. Pp. 366-391.

BUREAU OF THE CENSUS. *Vital Statistics—Special Reports. Washington, D.C.* Various numbers of Volume 20, State Summaries, as follows:

52, Hawaii; 53, Puerto Rico; 54, Virgin Islands; 55, Index.

DUNN, HALBERT L. [Prepared under the supervision of]. Vital Statistics of the United States, 1942. Pt. I. Natality and Mortality Data for the United States Tabulated by Place of Occurrence with Supplemental Tables for Hawaii,

Puerto Rico, and the Virgin Islands. Pp. iii + 176. $1.25. Pt. II. Natality and Mortality Data for the United States Tabulated by Place of Residence. *Washington* (Govt. Printing Office), 1944. Pp. iii + 533. 11¼ × 9¼ inches. $2.00.

GOOCH, MARJORIE. Maternal and infant mortality in the United States, 1942. *The Child,* 8: 179-185, 1944. Pp. (of reprint) 8.

LINDER, FORREST E. International vital statistics of the future. *Am. J. Pub. Health,* 34: 693-696, 1944.

MACDONALD, ELEANOR J. The state-wide cancer record registry in Connecticut. *The Med. Woman's J.,* Apr. 1944. Pp. (of reprint) 4.

MARTIN, W. J. The sex ratio of pneumonia mortality. *J. Hyg.,* 43: 315-327, 1944.

REGISTRAR-GENERAL'S Statistical Review of England and Wales for the Year 1939. (New Annual Series, No. 19). Tables. Part I. Medical. *London* (H. M. Stationery Office), 1944. Pp. vi + 338. 9⅝ × 6 inches. 5s (paper).

REGISTRAR-GENERAL'S Statistical Review of England and Wales for the Year 1939. (New Annual Series, No. 19. Tables. Part II. Civil. *London* (H. M. Stationery Office), 1944. Pp. vi + 130. 9⅝ × 6 inches. 2s (paper).

REGISTRAR-GENERAL'S Statistical Review of England and Wales for the Year 1940. (New Annual Series, No. 20). Tables. Part II. Civil. *London* (H. M. Stationery Office), 1944. Pp. vi + 94. 9⅝ × 6 inches. 1s. 6d.

TELEKY, AGNES. A note on the vital statistics of Iceland. *Brit. Med. J.,* 1: 597, 1944.

YERUSHALMY, J. Births, infant mortality, and maternal mortality in the United States, 1942. *Pub. Health Rep.,* 59: 797-810, 1944. [Bibliography of 2 titles.]

6. *Morbidity and Epidemiology*

DOPPLER, WILLIAM ARKWRIGHT [Prepared by]. Tuberculosis, Labor and Management. A Guide to Industrial Relations. *New York* (National Tuberculosis Assoc.), 1944. Pp. 52. 9 × 6 inches. [Bibliographies for most chapters.]

FOWLER, WILLIAM. The reportable diseases: diseases and conditions required to be reported in the several states. *Pub. Health Rep.,* 59: 317-340, 1944.

LEVIN, MORTON L. The epidemiology of cancer. From the viewpoint of the Health Officer. *Am. J. Pub. Health,* 34: 611-620, 1944. [Bibliography of 27 titles.]

LAEMMERT, H. W. Jr. Susceptibility of marmosets to different strains of yellow fever virus. *Am. J. Trop. Med.,* 24: 71-81, 1944. [Bibliography of 11 titles.]

LIGHT, JACOB S., and HORACE L. HODES. Studies on epidemic diarrhea of the newborn: isolation of a filtrable agent causing diarrhea in calves. *Am. J. Pub. Health,* 33: 1451-1454, 1943. [Bibliography of 1 title.]

UNITED STATES PUBLIC HEALTH SERVICE. The Notifiable Diseases: Prevalence of Certain Important Communicable Diseases, by States, 1942. *Washington* (Govt. Printing Office), 1944. Pp. 13. 9⅛ × 5⅞ inches. 5 cents.

7. *Natality, Fecundity, Fertility*

BUNDESEN, HERMAN N. The Baby Manual. A Practical Guide from Early Pregnancy through the Second Year of Life. Foreword by Thomas Parran. *New York* (Simon and Schuster), 1944. Pp. xii + 590. 8⅜ × 5⅝ inches. $3.00.

CASTALLO, MARIO A., and AUDREY WALZ. Expectantly Yours. A Book for Expectant Mothers and Prospective Fathers. Illustrated by Helen G. Schad. *New York* (Macmillan Company), 1943. Pp. xiii + 110. 7¾ × 5 inches. $1.75.

HOTCHKISS, ROBERT SHERMAN. Fertility in Men. With a Foreword by Nicholson J.Eastman. *Philadelphia* (J. B. Lippincott Company), 1944. Pp. xiii + 216. 9 × 6 inches. $3.50. [Bibliography for each chapter.]

SIEGLER, SAMUEL L. Fertility in Women. With a Foreword by Robert Latou Dickinson. *Philadelphia* (J. B. Lippincott Company), 1944. Pp. xv + 450. 9 × 6 inches. $4.50. [Bibliography for each chapter.]

8. *Birth Control*

[Vacant]

9. *Marriage and Divorce*

[Vacant]

III. BEHAVIOR

1. *Racial and Genetic Psychology*

ARMSTRONG, EDWARD A. The Way Birds Live. *London* (Lindsay Drummond, Ltd.), 1943. Pp. 96. 8½ × 5½ inches. 7s. 6d.

DU BOIS, CORA. The People of Alor. A Social-Psychological Study of an East Indian Island. With Analysis by Abram Kardiner and Emil Oberholzer. *Minneapolis* (Univ. Minnesota Press), 1944. Pp. xvi + 654. 9 × 6 inches. $7.50.

MEAD, MARGARET. The American Character. *New York* (245 5th Ave.) and *West Drayton, Middlesex, England* (Penguin Books), 1944. Pp. 173. 7⅛ × 4⅛ inches. 25 cents (paper).

2. *Individual Psychology*

ANASTASI, A., and J. P. FOLEY, Jr. An experimental study of the drawing behavior of adult psychotics in comparison with that of a normal control group. *J. Exper. Psychol.*, 34: 169-194, 1944. [Bibliography of 5 titles.]

BERRIEN, F. K. Practical Psychology. *New York* (Macmillan Company), 1944. Pp. xii + 584. 8⅜ × 5⅝ inches. $4.00. [Bibliography of 22½ pages.]

CHITTENDEN, GERTRUDE E. Living with Children. *New York* (Macmillan Company), 1944. Pp. ix + 163. 8 × 5¼ inches. $1.75. ["Additional Readings" for each chapter and a bibliography of "Reading Materials about Children and Their Families" of 7 pages.]

COOPER, MARCIA. Report of an experiment in mental hygiene. *Pub. Health Nursing*, Feb., 1944. Pp. (of reprint) 4.

DOLLARD, JOHN with the assistance of DONALD HORTON. Fear in Battle. *Washington* (The Infantry Journal), 1944. Pp. vii + 64. 7¼ × 5¾ inches (paper).

WECHSLER, DAVID. The Measurement of Adult Intelligence. 3d ed. *Baltimore*

(William and Wilkins Company), 1944. Pp. vii + 258. 9 × 6 inches. $3.50. [Bibliography of 2 pages.]

WHITE, WENDELL. Psychology in Living. *New York* (Macmillan Company), 1944. Pp. xviii + 333. 8 × 5¼ inches. $2.50. [Some bibliographic footnotes.]

WILL, NELL. The personality development of a stuttering boy. *etc.*, 1: 165-173, 1944.

3. *Psychiatry*

KARPMAN, BEN. Case Studies in the Psychopathology of Crime. A Reference Source for Research in Criminal Material. Vol. 2, Cases 6-9. *Baltimore* (Lord Baltimore Press), 1944. Pp. viii + 738. 10¾ × 8½ inches. $16.00.

MALZBERG, BENJAMIN. The expectation of an alcoholic mental disorder in New York State, 1920, 1930, and 1940. *Quart J. of Studies on Alcohol*, 4: 523-534, 1944.

VARIOUS AUTHORS. *Proceedings of the Second Brief Psychotherapy Council, Chicago, Ill., January, 1944.* I. War Psychiatry. Pp. 55. II. Psychosomatic Medicine. Pp. 64. III. Psychotherapy for Children. Pp. 58. *Chicago* (Inst. for Psychoanalysis), 1944. 9 × 6 inches. Single copy, 75 cents; set of three, $2.00 (paper). [Bibliography of 4 pages.]

4. *History and Biography*

DAMPIER, *Sir* WILLIAM CECIL. A Shorter History of Science. *New York* (Macmillan Company), 1944. Pp. x + 189. 7⅜ × 5 inches. $2.00. [Bibliography of 1½ pages.]

NYESSEN, D. J. H. The evolution of Eug. Dubois' conceptions. *Bol. de la Real Soc. Española de Hist. Natural*, 41: 459-464, 1943. [1 bibliographic footnote.]

PAGEL, WALTER. The Religious and Philosophical Aspects of van Helmont's Science and Medicine. *Supplements to the Bull. Hist. Med., No. 2. Baltimore* (Johns Hopkins Press), 1944. Pp. 44. 10 × 7 inches. $1.00 (paper). [Bibliographic footnotes throughout.]

RIDDLE, OSCAR. Charles Benedict Davenport. *Science*, 99: 441-442, 1944.

RODGERS, ANDREW DENNY, III. John Merle Coulter. Missionary in Science. *Princeton* (Princeton Univ. Press), 1944. Pp. ix + 321. 9¼ × 6 inches. $3.75. [Some bibliographic footnotes.]

STEGGERDA, MORRIS. Charles Benedict Davenport (1866-1944); the man and his contributions to physical anthropology. *Am. J. Physical Anthrop.*, New Ser. 2: 167-185, 1944. [2 bibliographic footnotes.]

TERRIS, MILTON. An early system of compulsory health insurance in the United States, 1798-1884. *Bull. Hist. of Med.*, 15: 433-444, 1944. [Bibliography of 12 titles.]

5. *Sociology, Law, Politics and Religion*

HOFSTADTER, RICHARD. Social Darwinism in American Thought, 1860-1915. *Philadelphia* (Univ. Penna. Press), 1944. Pp. viii + 191. 10¾ × 8½ inches. $2.50. [Bibliographic footnotes throughout and bibliography of 10 pages.]

KISER, CLYDE V., and LOUISE K. KISER. Race conditions in the United States. Reprinted from *The American Yearbook, New York* (Thomas Nelson and Sons), 1944. Pp. 545-556.

MOSCOW DECLARATION OF OCTOBER 30, 1943. A Design for a Charter of the General International Organization. *New York* (Milbank Mem. Fd. Quart.), Aug. 1, 1944. Pp. 23. 8¼ × 5¾ inches.

6. *Economics*

KIESSLING, OSCAR E., and NICHOLAS YAWORSKI [Prepared under the supervision of]. Mineral Industries 1939. Vol. I. General Summary and Industry Statistics. *Washington* (Govt. Printing Office), 1944. Pp. viii + 876. 11¾ × 9¼ inches. $2.75.

LEAGUE OF NATIONS. International Currency Experience. Lessons of the Inter-War Period. *New York* (Columbia Univ. Press), 1944. Pp. 249. 9 × 6 inches. $3.25 (paper). [Some bibliographic footnotes.]

WAGGAMAN, MARY T. Family Allowances in Various Countries. *Bull. No. 754 of the United States Bureau of Labor Statistics. Washington* (Govt. Printing Office), 1943. Pp. iii + 62. 9⅛ × 5⅞ inches. 10 cents (paper). [122 bibliographic footnotes.]

WYATT, S. A study of variations in output. *Medical Research Council. Emergency Report No. 5 of the Industrial Health Research Board. London* (H. M. Stationery Office), 1944. Pp. iv + 16. 9⅝ × 6 inches. 4d. [3 bibliographic footnotes.]

7. *Education*

COBB, W. MONTAGUE. Education: priority number one. *Phylon*, 4th Quart.: 305-310, 1943. [1 bibliographic footnote.]

NORWOOD, WILLIAM FREDERICK. Medical Education in the United States Before the Civil War. Foreword by Henry E. Sigerist. *Philadelphia* (Univ. Penna. Press), 1944. Pp. xvi + 487. 9¼ × 6⅛ inches. $6.00. [Many bibliographic footnotes and bibliography of 27 pages.]

U. S. OFFICE OF EDUCATION. Conference Workbook on Problems of Post-War Higher Education. *Washington* (Govt. Printing Office), 1944. Pp. 38. 9⅛ × 5⅞ inches. 10 cents (paper).

WOLMAN, ABEL, ALFRED H. FLETCHER, and WILMER H. SCHULZE. Favorable and adverse developments in the school environment. *Am. J. Pub. Health*, 34: 484-488, 1944.

WOODY, CLIFFORD. Some next steps in teacher education. *J. Educ. Research*, 37: 670-683, 1944.

8. *Ethnology, Cultural Anthropology, Travel and Exploration*

BOHDANOWICZ L. The Polish Tatars. *Man*, 44: 116-121, 1944.

CHANG, YIN-TANG. Anthropological features of the Shans and their geographical environment in south-west Yunnan. *Man*, 44: 61-68, 1944. [6 bibliographic footnotes.]

CLIFFORD, MILES. Notes on the Bassa-Komo tribe in the Igala division, Nigeria. *Man*, 44: 107-116, 1944. [1 bibliographic footnote.]

COON, CARLETON S. and JAMES M. ANDREWS, IV (Eds.). Studies in the Anthropology of Oceania and Asia presented in memory of Roland Burrage Dixon, by JAMES ANDREWS, IV, GORDON T. BOWLES, CARLETON S. COON, KENNETH P. EMORY, JAMES H. GAUL, EDWARD W. CRAIGHILL HANDY, W. W. HOWELLS, FREDERICK S. HULSE, RALPH LINTON, LI CHI, GORDON MACGREGOR, DOUGLAS L. OLIVER, HARRY L. SHAPIRO, and R. LAURISTON SHARP. *Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University*, Vol. XX. *Cambridge, Mass.* (Museum Press), 1943. Pp. xiv + 220 + 20 plates. 10⅝ × 7⅝ inches. $4.50 (paper); $6.00 (cloth). ["References Cited" for most papers.]

HRDLIČKA, ALĚS. Alaska Diary, 1926-1931. *Lancaster* (Jaques Cattell Press), 1943. Pp. xv + 414. 9¼ × 6¾ inches. $5.00.

JANSE, OLOV R. T. The Peoples of French Indochina. *Smithsonian Institution War Background Studies Number Nineteen.* (*Publication* 3768.). *Washington* (Smithsonian Instn.), 1944. Pp. 28 + 25 plates. 9 × 6 inches. Free (paper). [Bibliography of 1 page.]

KIDDER, ALFRED. II. Some early sites in the northern Lake Titicaca Basin. Expeditions to Southern Peru, Peabody Museum, Harvard University, Report No. 1. *Papers of the Peabody Museum of Am. Arch. and Ethnol., Harvard Univ.*, Vol. 27, No. 1. *Cambridge* (Peabody Mus.), 1943. Pp. 48 + 7 plates. 10⅝ × 7¾ inches. $1.25 (paper). [Bibliography of 1⅓ pages.]

KLUCKHOLM, CLYDE. Navaho witchcraft. *Papers of the Peabody Museum of Am. Arch. and Ethnol., Harvard Univ.*, Vol. 22, No. 2. *Cambridge* (Peabody Mus.) 1944. Pp. 150. 10⅝ × 7¾ inches. $2.25 (paper). [Bibliography of 4¼ pages.]

LASKER, BRUNA. Peoples of Southeast Asia. Prepared under the Auspices of The American Council of the Institute of Pacific Relations. *New York* (Alfred A. Knopf), 1944. Pp. viii + 288 + x. 8⅜ × 5⅝ inches. $3.00.

PEAKE, HAROLD J. E. The fencing of early tombs. *Man*, 44: 58-61, 1944. [Bibliography of 22 titles.]

TITIEV, MISCHA. Old Oraibi: A Study of the Hopi Indians of Third Mesa. *Papers of the Peabody Museum of Am. Arch. and Ethnol., Harvard Univ.*, Vol. 22, No. 1. *Cambridge, Mass.* (Museum Press), 1944. Pp. xi + 277 + 4 plates. 10⅝ × 7⅝ inches. $4.50 (paper). [Bibliography of 5½ pages.]

WENLEY, A. G. and JOHN A. POPE. China. *Smithsonian Institution War Background Studies Number Twenty.* (*Publication* 3770.) *Washington, D.C.* (Smithsonian Instn.), 1944. Pp. v + 85 + 25 plates. 9 × 6 inches. Free (paper).

WHYTE, WILLIAM FOOTE. Age-grading of the Plains Indians. *Man*, 44: 67-72, 1944. [Many bibliographic footnotes.]

IV. SOMATOLOGY AND CONSTITUTION

1. *Anatomy*

BAILEY'S Text-Book of Histology. 11th ed. Revised by PHILIP E. SMITH and

WILFRED M. COPENHAVER with the assistance of AURA E. SEVERINGHAUS and CHARLES M. GOSS. *Baltimore* (Williams and Wilkins), 1944. Pp. xx + 786. 9 × 6 inches. $6.00. ["References" for each chapter.]

BRADLEY, O. CHARNOCK. Topographical Anatomy of the Dog. 4th ed. Revised by TOM GRAHAME. *New York* (Macmillan Company), 1943. Pp. xii + 316. 9¾ × 6 inches. $7.50.

COBB, W. MONTAGUE. The artistic canons in the teaching of anatomy. *J. Natl. Med. Assoc.*, 36: No. 1: 3-14, 1944. [Bibliography of 25 titles.]

2. *Physical Anthropology and Anthropometry*

GAMBLE, DAVID P. Physical type and mental characters. Preliminary notes on the study of the correlation between racial types and types of psychotic reaction. *Am. J. Physical Anthrop.*, New Ser. 2: 195-220, 1944. [Bibliography of 3 titles.]

HEYNS, O. S. and S. S. HERSCH. The birth-weight of urban Bantu, including a consideration of the incidence of antenatal syphilis, still-birth and premature labour. *South African J. M. Sc.*, 9: 33-39, 1944. [Bibliography of 8 titles.]

LANIER, RAYMOND R., Jr. Length of first, twelfth, and accessory ribs in American Whites and Negroes; their relationship to certain vertebral variations. *Am. J. Physical Anthrop.*, New Ser. 2: 137-146, 1944. [Bibliography of 22 titles.]

3. *Constitution*

[Vacant]

V. PHYSIOLOGY AND BIOCHEMISTRY

1. *Physiology*

BABKIN, B. P. Secretory Mechanism of the Digestive Glands. *New York* and *London* (Paul B. Hoeber, Inc.), 1944. Pp. xix + 900. 9¼ × 6 inches. $12.75. [Bibliography of 86 pages.]

BEST, CHARLES HERBERT, and NORMAN BURKE TAYLOR. The Living Body. A Text in Human Physiology. Revised ed. *New York* (Henry Holt), 1944. Pp. xxii + 569. 8½ × 5½ inches. $3.90.

BLACK, JOHN D. Food Enough. *Lancaster* (Jaques Catell Press, 1943. Pp. vii + 269. 7½ × 5⅜ inches. $2.50.

CAWSTON, F. GORDON. The alleged shedding of anchylosed and socketted teeth by means other than that of vertical succession. *South African Dental J.*, 18:49-53, 1944. [Bibliography of 10 titles.]

CREED, MARGARET L. The nutritional value of a poor South African dietary and of certain dietary supplements, as tested on rats. *South African J. M. Sc.*, 9: 21-30 + 1 plate, 1944. [Bibliography of 25 titles.]

MICHELSON, NICHOLAS. Studies in the physical development of negroes. IV. Onset of puberty. *Am. J. Physical Anthrop.*, New Ser. 2: 151-166, 1944. [Bibliography of 19 titles.]

RIDDLE, OSCAR, GUINEVERE C. SMITH, and RICHARD A. MILLER. The effect of

adrenalectomy on heat production in young pigeons. *Am. J. Physiol.*, 141: 151-157, 1944. [Bibliography of 11 titles.]

SHERMAN, HENRY C., and CAROLINE SHERMAN LANFORD. An Introduction to Foods and Nutrition. *New York* (Macmillan Company), 1943. Pp. viii + 292. 8 × 5⅜ inches. $2.50

SMITH, GUINEVERE C., and OSCAR RIDDLE. Effects of fasting on the respiratory metabolism of normal and hypophysectomized young pigeons. *Am. J. Physiol.*, 141: 303-311, 1944. [Bibliography of 15 titles.]

2. *Senescence, Senility and Longevity*

GREVILLE, T. N. E. La longevidad rural comparada con la urbana. *Estadística*, 2: 255-257, 1944. [1 bibliographic footnote.]

GUMPERT, MARTIN. You Are Younger Than You Think. *New York* (Duell, Sloan and Pearce), 1944. Pp. ix + 244. 8 × 5¼ inches. $2.75. [Bibliography of 3 pages.]

3. *Biochemistry*

HOLMES, ARTHUR D., FRANCIS TRIPP, *et al.* Ascorbic acid content of cow's milk after five years of continuous lactation. *Food Research*, 7: 370-372, 1942. [Bibliography of 4 titles.]

HOLMES, ARTHUR D., FRANCIS TRIPP, *et al.* Ascorbic acid content of cow's milk during four successive lactation periods. *Food Research*, 8: 237-242, 1943. [Bibliography of 10 titles.]

HOLMES, ARTHUR D., FRANCIS TRIPP, *et al.* Relation of volume of daily milk production to ascorbic acid content of cow's milk. *Food Research*, 7: 111-117, 1942. [Bibliography of 10 titles.]

JACOBS, MORRIS B. [Ed.] and a Group of Specialists. The Chemistry and Technology of Food and Food Products. Vol. 1. *New York* (Interscience Publ. Co.), 1944. Pp. xv + 952. 9⅝ × 6½ inches. $10.50. [Some bibliographic footnotes.]

JONES, IVAN D., and JOHN L. ETCHELLS. Nutritive value of brined and fermented vegetables. *Am. J. Pub. Health*, 34: 711-718, 1944. [Bibliography of 17 titles.]

LUCK, JAMES MURRAY, and JAMES H. C. SMITH [Eds.]. Annual Review of Biochemistry, Vol. 13. *Stanford Univ.* (Annual Reviews, Inc.), 1944. Pp. ix + 795. 8¾ × 6 inches. $5.00. [Bibliography for each chapter.]

MARKLEY, KLARE S., and WARREN H. GOSS. Soybean Chemistry and Technology. *Brooklyn* (Chemical Publ. Co.), 1944. Pp. vii + 261. 8½ × 5½ inches. $3.50. ["Literature Cited" of 6 pages.]

NORD, F. F. and C. H. WERKMAN [Eds.]. Advances in Enzymology and Related Subjects of Biochemistry. Vol. IV. *New York* (Interscience Publishers), 1944. Pp. viii + 332. 9 × 6 inches. $5.50. [Bibliography for each chapter.]

PLENTL, ALBERT A., and IRVINE H. PAGE. The action of crystalline proteolytic enzymes on angiotonin. *J. Exper. Med.*, 79: 205-214, 1944. [Bibliography of 19 titles.]

RIDDLE, OSCAR. Animal hormones affecting growth and several effects of single hormones. *Torreya*, 43: 96-97, 1943.

RIDDLE, O., W. F. HOLLANDER, *et al.* Endocrine studies. *Carnegie Instn., of Washington Year Book No.* 42, pp. 129-139, 1943.

SATTERFIELD, G. HOWARD, E. A. BAILEY, Jr., *et al.* The ascorbic acid content of ewes' blood, colostrum and milk and the effect of ascorbic acid injections. *J. Nutrition*, 24: 121-129, 1942. [Bibliography of 17 titles.]

SATTERFIELD, G. HOWARD, R. E. CLEGG, and ARTHUR D. HOLMES. Vitamin A content of sheep's colostrum and milk. *Food Research*, 9: 206-211, 1944. Pp. (of reprint) 6. [Bibliography of 15 titles.]

SHONLE, H. A. and A. M. VANARENDONK. Unsymmetrical diacyl derivatives of 4,4'-diaminodiphenyl sulfone. *J. Am. Chem. Soc.*, 65: 2375-2377, 1943. [6 bibliographic footnotes.]

VARIOUS AUTHORS. Emulsion Technology: Theoretical and Applied. *Brooklyn* (Chemical Publ. Co.), 1943. Pp. xi + 290. 8½ × 5½ inches. $5.00. ["References" for each chapter.]

WILLIS, L. G. [Originally compiled by]. Bibliography of References to the Literature on the Minor Elements and Their Relation to Plant and Animal Nutrition. 5th supp. to 3rd ed. *U. S. A.* (Chilean Nitrate Educational Bureau, Inc.), 1944. Pp. 96. 11 × 8½ inches. Free (paper).

WISE, LOUIS E. [Ed.], and 14 contributing authors. Wood Chemistry. *New York* (Reinhold Publishing Corporation), 1944. Pp. x + 900. 9½ × 6 inches. $11.50. [Bibliographic footnotes for some sections and reference lists for some sections.]

4. *Pharmacology*

EAGLE, HARRY, RALPH B. HOGAN, *et al.* The therapeutic efficacy of phenyl arsenoxides in mouse and rabbit trypanosomiasis *(Tryp. equiperdum)*. *Pub. Health Rep.*, 59: 765-783, 1944. [Bibliography of 14 titles.]

HILTY, W. W. Determination of ephedrine by kjeldahl distillation. *J. Am. Pharm. Assoc.*, 33: 28-29, 1944.

KOPROWSKI, HILARY, and EDWIN H. LENNETTE. Sulfonamides in yellow fever virus infections of mice and developing chick embryos. *Am. J. Hyg.*, 40: 14-25, 1944. [Bibliography of 35 titles.]

SANDGROUND, J. H. and C. R. HAMILTON. Studies on the detoxication of organic arsenical compounds. IV. The protective action of P-aminobenzoic acid against lethal doses of neoarsphenamine without inhibition of trypanocidal potency. *J. Lab. and Clin. Med.*, 28: 1821-1827, 1943. Pp. (of reprint) 8. [Bibliography of 14 titles.]

VI. PATHOLOGY, CLINICAL MEDICINE AND SURGERY

ASCHNER, BERNARD. The Art of the Healer. *New York* (Dial Press), 1942. Pp. viii + 306. 8⅛ × 5⅜ inches. $2.75.

BAETJER, ANNA M., and FREDERICK J. VINTINNER. The effect of silica and feldspar dusts on susceptibility to lobar pneumonia. *J. Indust. Hyg. and Toxicol.*, 26: 101-108, 1944. [Bibliography of 22 titles.]

BAYNE, J. BRECKINRIDGE. Bugs and Bullets. *New York* (Richard R. Smith), 1944. Pp. 256. 8⅛ × 5½ inches. $2.75.

BEST, HARRY. Deafness and The Deaf in the United States. *New York* (Macmillan Company), 1944. Pp. xix + 675. 9¼ × 6 inches. $6.50. [Bibliographic footnotes throughout.]

BOYD, MARK F. Present day problems of malaria infections. *J. A. M. A.*, 124: 1179-1187, 1944. Pp. (or reprint) 28. [25 bibliographic footnotes.]

CAUSEY, OTTIS R., and CALISTA ELIOT CAUSEY. Sobre a ocorrência da brucelose no estado do Ceará, Brasil. *O Hosptial*, Sept., 1942. Pp. (of reprint) 3.

DAELE, P. F. VAN DEN. Something New About Health and Healing. *Boston* (Christopher Publ. House), 1944. Pp. 288. 7¾ × 5¼ inches. $3.00.

DAVENPORT, CHARLES B., CLYDE E. KEELER, MAUDE SLYE, and MADGE T. MACKLIN. Medical Genetics and Eugenics. Vol. I. *Philadelphia* (Women's Medical College), 1944. Pp. 141. 9¼ × 6¼ inches. $1.00. [Bibliography for some chapters.]

EATON, MONROE D., WILLIAM D. MURPHY, and V. LEE HANFORD. Hetrogenetic anti bodies in acute hepatitis. *J. Exper. Med.*, 79: 539-557, 1944. [Bibliography of 28 titles.]

FRANCIS, THOMAS, JONAS E. SALK, HAROLD E. PEARSON, and PHILIP N. BROWN. Protective effect of vaccination against induced Influenza A. *Soc. Exper. Biol. and Med.*, 55: 104-105, 1944. [3 bibliographic footnotes.]

FRIEDEWALD, WILLIAM F. Enhancement of the immunizing capacity of influenza virus vaccines with adjuvants. *Science*, 99: 453-454, 1944.

GATES, R. RUGGLES, LAURENCE H. SNYDER, and EARNEST A. HOOTON. Medical Genetics and Eugenics. Vol. 2. *Philadelphia* (Woman's Medical College of Pennsylvania), 1943. Pp. 60. 9 × 5¾ inches. $1.00.

KOPROWSKI, HILARY, and EDWIN H. LENNETTE. Propagation of yellow fever virus in tissue cultures containing sulfonamides. *Am. J. of Hyg.*, 40: 1-13, 1944. [Bibliography of 19 titles.]

MACDONALD, ELEANOR J. A report of living individuals who have had proved cancer. *Conn. Health Bull.*, 58: No. 4, 1944. Pp. (of reprint) 4.

MEIKLEJOHN, GORDON, M. DORTHY BECK, and MONROE R. EATON. Atypical pneumonia caused by psittacosis-like viruses. *J. Clin. Investigation*, 23: 167-175, 1944. [Bibliography of 25 titles.]

NIGG, CLARA, and MONROE D. EATON. Isolation from normal mice of a pneumotropic virus which forms elementary bodies. *J. Exper. Med.*, 79: 497-510 + 1 plate, 1944. [Bibliography of 18 titles.]

PEREIRA, JACY ROIZ, and JAIR ROIZ PEREIRA. Treatment of essential arterial hypertension. *Report to the Academia Nacional de Medicina*, Aug. 19, 1943. Pp. (of reprint) 8.

ROWE, ALBERT H. Elimination Diets and the Patients Allergies. A Handbook of Allergy. 2nd ed, thoroughly revised. *Philadelphia* (Lea and Febiger), 1944. Pp. 256. 5¾ × 9⅛ inches. $3.50.

SOPER, FRED L. Febre amarela panamericana, 1938 a 1942. *IX Conferencia Sanitaria Panamericana, Washington, D. C.*, Dec., 1942. Pp. (of reprint) 12.

TAYLOR, A. R., D. G. SHARP, *et al.* Purification and character of the swine-influenza virus. *J. Immunol.*, 48: 361-379, 1944. [Bibiliography of 18 titles.]

VII. METHODOLOGY

1. *Mensurational and Observational*

BEARD, J. W., D. G. SHARP, *et al.* Ultracentrifugal, chemical and electron microscopic identification of the influenza virus. *South M. J.*, 37: 313-320, 1944. Pp. (of reprint) 18. [Bibliography of 29 titles.]

BEVAN, C. DE V. Cultivation of South African rickettsiae in developing chicks and the preparation of vaccines from their membranes. *South African J. M. Sc.*, 9: 1-20 + 1 plate, 1944. [Bibliography of 18 titles.]

DYER, BRIAN R., and T. R. BHASKARAN. Investigations of ground-water pollution. Pt. 1. Determination of the direction and the velocity of flow of ground water. *Indian J. M. Research*, 31: 231-243, 1943. [Bibliography of 7 titles.]

HARROWER-ERICKSON, M. R. The Rorschach test. *J. A. A. M. C.*, 19: 193-201, 1944. [Bibliography of 10 titles.]

LAHR, ERNEST L., ROBERT W. BATES, and OSCAR RIDDLE. Non-specific results obtained with micro-method for assay of prolactin. *Endocrinology*, 32: 251-259, 1943. [Bibliography of 6 titles.]

MORAES, O. ALEXANDER DE. O recenseamento de 1940 do ponto de vista da tecnica censitaria. *Estadística*, 2: 189-207, 1944.

TEMPLETON, FREDERIC E. X-Ray Examination of the Stomach. A Description of the Roentgenologic Anatomy, Physiology, and Pathology of the Esophagus, Stomach, and Duodenum. *Chicago* (Univ. Chicago Press), 1944. Pp. iv + 516. 9 × 6 inches. $10.00. [Bibliography of 14 pages.]

2. *Mathematical and Statistical*

EDWARDS, THOMAS I., and LOUIS P. HELLMAN. Methods used in processing data from the physical examination reports of the selective service system. *J. Am. Statist. A.*, 39: 165-182, 1944. [Some bibliographic footnotes.]

HILL, HIBBERT WINSLOW. "Speed of reaction" hypothesis: its numerical foundations in respect to the tubercle bacillus. *Am. Rev. Tuberc.*, 59: 414-422, 1944. [Bibliography of 1 title.]

LEMKAU, PAUL, CHRISTOPHER TIETZE, and MARCIA COOPER. A survey of statistcial studies on the prevalence and incidence of mental disorder in sample populations. *Pub. Health Rep.*, 58: 1909-1927, 1943. [Bibliography of 43 titles,]

MÍCHALUP. ERIC. Nota acerca del ajustamiento mecánico. *Estadística*, 2: 208-222, 1944. [Some bibliographic footnotes.]

3. *Other and General*

PIPER, C. S. Soil and Plant Analysis. A Laboratory Manual of Methods for the Examination of Soils and the Determination of the Inorganic Constituents of Plants. *New York* (Interscience Publishers, Inc.), 1944. Pp. xv + 368. 8½ × 5½ inches. $4.50. ["References" for each chapter.]

ZELIFF, C. COURSON. Laboratory Manual for Introductory Zoology. *Harrisburg, Penna.* (Evangelical Press), 1944. Pp. 144. 9 × 6 inches. $1.50 (paper).

VIII. GENERAL AND MISCELLANEOUS

BACHMEYER, ARTHUR C., and GERHARD HARTMAN [Eds.]. The Hospital in Modern Society. *New York* (Commonwealth Fund), 1943. Pp. xiv + 768. 9¼ × 6 inches. $5.00. ["References" for each chapter.]

BOARDMAN, EDWARD T. Guide to Higher Aquarium Animals. *Cranbrook Institute of Science Bull. No. 21. Bloomfield Hills, Mich.* (Cranbrook Press), 1944. Pp. 107. 9 × 6 inches. $2.00.

CORNER, GEORGE W. Ourselves Unborn. An Embryologist's Essay on Man. *New Haven* (Yale Univ. Press), 1944. Pp. xiv + 188. 8 × 5⅜ inches. $3.00. [Bibliography of 3½ pages.]

DORLAND, W. A. NEWMAN [with the collaboration of E. C. L. MILLER]. The American Illustrated Medical Dictionary. A Complete Dictionary of the Terms Used in Medicine, Surgery, Dentistry, Pharmacy, Chemistry, Nursing, Veterinary Science, Biology, Medical Biography, etc., with the Pronunciation, Derivation, and Definition. 20th ed., revised and enlarged. *Philadelphia* and *London* (W. B. Saunders Company), 1944. Pp. 1668, 9⅛ × 5⅞ inches. $7.50.

HUXLEY, JULIAN. On Living in a Revolution. *New York* and *London* (Harper and Brothers), 1944. Pp. xiv + 242. 8⅛ × 4⅞ inches. $2.50.

JAEGER, EDMUND C. A Source-book of Biological Names and Terms. *Springfield, Ill.* (Charles C Thomas), 1944. Pp. xxvi + 256. 9½ × 6¼ inches. $3.50.

JAFFE, BERNARD. Men of Science in America. The Rôle of Science in the Growth of Our Country. *New York* (Simon and Schuster), 1944. Pp. xl + 600. 8½ × 5⅜ inches. $3.75. [Bibliography of 16 pages.]

JEAN, FRANK COVERT, EZRA CLARENCE HARRAH, and FRED LOUIS HERMAN with the editorial collaboration of SAMUEL RALPH POWERS. Man and His Biological World. *Boston* (Ginn and Company), 1944. Pp. 631. 9 × 6⅛ inches. $3.50 [Some bibliographic footnotes.]

JOKL, Captain ERNST. Medical Aspects of Aviation (Speed and Acceleration). Illustrated by E. Ullman. *London* (Pitman and Sons, Ltd.), 1943. Pp. xiii + 104. 8½ × 5⅜ inches. 10/6.

MATHESON, ROBERT. Entomology for Introductory Courses. *Ithaca* (Comstock Publ. Co.), 1944. Pp. xiv + 600. 9¼ × 6¼ inches. $5.50. [Bibliography of 16 pages.]

MEARS, ELIOT G. Pacific Ocean Handbook. *Stanford Univ.* (James Ladd Delkin), 1944. Pp. x + 198 + 1 folding map. 6¾ × 3⅞ inches. $1.00 (paper).

MEMBERS OF THE FACULTIES OF THE UNIVERSITY OF CALIFORNIA. Science in the University. *Berkeley* (Univ. California Press), 1944. Pp. x + 332. 9¼ × 6 inches. [Bibliographies for some sections.]

MULLER, H. J. Science and Criticism. The Humanistic Tradition in Contemporary Thought. *New Haven* (Yale Univ. Press), 1944. Pp. xiv + 303. 9¼ × 6⅛ inches. $3.75. [Some bibliographic footnotes.]

RIDDLE, OSCAR. Should Euthanasia Be Made Lawful? *New York* (Society for Medical Jurisprudence), 1943. Pp. 5. 10 × 7 inches (paper).

SMITH, GEDDES, and LESTER J. EVANS. Preventive medicine: an attempt at a definition. *Science*, 100: No. 2586: 39-42, 1944. Pp. (of reprint) 3.

STEPHENSON, T. A. Seashore Life and Pattern. *London (King Penguin Books)*, 1944. Pp. 28 + 16 colored plates. 7 × 4¾ inches. 2s. (paper).

STEVENS, MONTAGUE. Meet Mr. Grizzly. A Saga of the Passing of the Grizzly. *Albuquerque* (Univ. of New Mexico), 1943. Pp. x + 281. 9 × 6 inches. $3.50.

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